PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

MAY 4 1922

ENGINEERING:

Engineering Library

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXIII.—No. 2933.] *LONDON: FRIDAY, APRIL 21, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd., ROCHESTER. 9063

Steam Road Rollers & Tractors.

A. G. Mumford, Ltd., CULVER STREET WORKS, COLCHESTER. OIL ADMIRALTY AND WAR OFFICE LISTS. ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS. See advertisements pages 56 and 61. PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS. And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant OF ALL DESCRIPTIONS. FLOATING CRANES, COAL BUNKERING VESSELS.

Werf Conrad, HAARLEM, HOLLAND. Agents: MARIPE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2. See half-page Advert. last cover and next week. 975

Cranes.—Electric, Steam, HYDRAULIC and HAND, of all types and sizes. GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9048

STEEL TANKS, PIPES, GASHOLDERS, &c.

Thos. Piggott & Co., Limited, BIRMINGHAM. 1411 See Advertisement last week, page 91.

"Spencer-Hopwood" Patent WATER TUBE **Boilers.** See page 72. Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives. Specification and Workmanship equal to Main Line Locomotives. R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9044

Cochran MULTITUBULAR AND CROSS-TUBE TYPES. **Boilers.** See page 17. 9047

Petter Oil Engines. For Paraffin and Crude Oil. Sizes 1½ B.HP. and upwards.

Petters Limited, Yeovil. Sizes 25 to 500 B.HP.

Vickers-Petters, Ltd., Ipswich See advertisement alternate weeks. 2038

Invincible Gauge Glasses.

BUTTENWORTH BROS., Ltd., Newton Heath Glass Works, Manchester. Od 6735

Electric Cranes.

S. H. HEYWOOD & CO., LTD., REDDISH. 9069

Fuller, Horsey, Sons & Cassell. SPECIALISTS in the SALE AND VALUATION of PLANT AND MACHINERY and ENGINEERING WORKS 11, BILLITER SQUARE, E.C.3. 1506

Iron and Steel

Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2046

The Scottish Tube Co., Ltd., HEAD OFFICE: 24, Robertson Street, Glasgow. See Advertisement page 77, April 14.

Yarrow & Co., Ltd., SHIPBUILDERS AND ENGINEERS, GLASGOW. SPEEDS UP TO 45 MILES AN HOUR. PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.

Repairs on Pacific Coast by YARROWS, LIMITED, Victoria, British Columbia. 9043 SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd. Gear Cutting.

Worm Wheels cut up to 13 ft. diam. Bevel and Mitre Wheels planed up to 3 ft. diam. Spur Wheels cut up to 9 ft. diam. DOLPHIN FOUNDRY, LEEDS. 4947

Vosper & Co., Ltd., PORTSMOUTH. SHIP & LAUNCH BUILDERS. Od 2951 ENGINEERS & BOILER MAKERS

Cement.—Maxted & Knott, LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1869. Address, BURNETT AVENUE, HULL. Cablegrams: "Energy, Hull." 9765

OIL FUEL APPLIANCES, *Systems* PRESSURE, AIR, STEAM *For Boilers of all types.* KERMODES LIMITED, 58, The Temple, Dale Street, Liverpool. *Naval Outfits a Specialty,* also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds. Supplied to the British and other Governments. Telephone No.: Central 2626. Telegrams: "Warmth." 4078

Locomotives Tank Engines designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2937 See their Illus. Advertisement, page 97 last week. RAILWAY AND TRAMWAY ROLLING STOCK.

Hurst, Nelson & Co., Ltd. THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3393

R. Y. Pickering & Co., Ltd., (ESTABLISHED 1864.) BUILDERS of RAILWAY CARRIAGES & WAGONS. MAKERS of WHEELS and AXLES of all kinds. RAILWAY WAGONS FOR HIRE. Chief Works and Offices: WISHAW, near GLASGOW. London Office: 5, VICTORIA STREET, WESTMINSTER, S.W. Od 3393

Henry Butcher & Co., AUCTIONEERS, VALUERS AND SURVEYORS for ENGINEERING AND ALLIED TRADES and INDUSTRIAL PROPERTIES. 9066 63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters.

S. H. HEYWOOD & CO., LTD., REDDISH. 9063

John H. Wilson & Co., Ltd., Birkenhead.

See Illustrated Advertisement Page 139, Jan. 20, 1922.

Locomotive Shunting Cranes

Steam and Electric Cranes EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS, SHIPS' WINDLASSES, WINCHES, and DOCK MACHINERY. 637 LISTS OF STANDARD SIZES ON APPLICATION.

London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited, MILLWALL, LONDON, E. 1218 GENERAL CONSTRUCTIONAL ENGINEERS,

Boilers, Tanks, & Mooring Buoys STILLS, PETROL TANKS AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd., Glasgow and Birmingham.

See Advertisement page 54. 9050

Economy!

HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING

Todd Oil Burners FUEL OIL BURNING SYSTEMS. HEATERS, STRAINERS. 45-51, HASTINGS, LONDON, E.C.2.

TODD SHIPYARDS CORPORATION, Builders of Steam and Motor Ships. Repairers. Electric Drive Installations. Twenty-one Floating Docks, Two Graving Docks. Twelve Shipways. 26, Broadway, New York, U.S.A. 9060

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD., London Office—12, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES, CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 140

FOR **Drop Forgings** write GARTSHERRIE ENGINEERING & FORGE CO., 82, Wellington Street, Glasgow. 9074

ON ADMIRALTY LIST.

John Kirkaldy, Ltd., London Office: 101, LEADENHALL ST., E.C.3. Works: SUDBURY, near HARROW, MIDDX. Makers of Evaporating and Distilling Plants, Refrigerating and Ice Making Machinery, Feed Water Heaters, Evaporators, Fresh Water Distillers, Main Feed Pumps, Combined Circulating and Air Pumps, Auxiliary Surface Condensers, &c. &c. 9031

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Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALCIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. Now's Patents. Merrill's Patent LINK STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS. REDUCING VALVES. Right-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5722

Yarrow Patent Water-tube Boilers. Messrs. YARROW & CO. UNDERTAKE the FRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities. YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd. Dumbarton. LEVENFORD WORKS, 9033 See Full Page Advt., page 63, March 31.

Forgings.

Walter Somers, Limited, HALESOWEN. 2116

Head, Wrightson & Co., LIMITED.

See Advertisement page 57. 9059

Taylor & Challen Presses 2106 About 300 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices. TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM. See Full page Advertisement, page 96, March 31.

Railway Switches and Crossings.

T. SUMMERSON & SONS, LIMITED, DARLINGTON. 605

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GRAPHITED GREASE. "GREDAG" 9040

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Locomotive Traversers (ELECTRIC).

S. H. HEYWOOD & CO., LTD., REDDISH. 9063

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Centrifugals.

Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 9027

See half-page Advertisement page 42, April 14.

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9863
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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement pages 29 and 61.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES, COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2.
See half-page Advert. last week and next week. 675

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9048

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited, BIRMINGHAM. 7411
See Advertisement last week, page 91.

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Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
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For Paraffin and Crude Oil.
Sizes 1½ B.HP. and upwards.
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Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9535

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9783

Electric Cranes.
9662
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PLANT AND MACHINERY
and
ENGINEERING WORKS.
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Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 5746
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 77, April 14.

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PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
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Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3951
ENGINEERS & BOILER MAKERS.

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Address, BURNETT AVENUE, HULL.
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Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
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Naval Outfits a Speciality,
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Supplied to the British and other Governments.
Telephone No.: Central 2833.
Telegrams: "Warmth." 4078

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THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3363

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(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
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London Office: Od 3353
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AUCTIONEERS, VALUERS AND SURVEYORS
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ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 9806
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 9662
REDDISH.

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 26, 1921.

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EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 637
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited,
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GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 55. 9042

Economy!
HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING
Todd Oil Burners
FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS.
49-51, EASTCHEAP, LONDON, E.C. 3.
TODD SHIPYARDS CORPORATION,
Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways.
25, Broadway, New York, U.S.A. 9060

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 540

FOR
Drop Forgings write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 9674
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John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURY HILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9604

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(UP TO 35 TONS.)
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All classes of mechanical and structural work undertaken. Special plants designed and supervised during erection. Contracts for plant and machinery handled and supervised throughout.
OWEN & CRISP,
84, Basinghall Street, London, E.C.2.
Telephone No.: London Wall 5666. 9660

Diesel Engines, Six Cylinder,
two and four stroke, 350, 1000, 1200 HP. Excellent condition. Dynamos for above 250 or 500 Volts, D.C. Immediate delivery and low price.
Also 2-500 Kw. PARSONS TURBINE SETS, 250 or 500 Volts D.C., with Condenser and spare armature.
ELECTRICALLY DRIVEN AIR COMPRESSORS, 250 Volts D.C. Pressures 1500 to 3000 lbs. per square inch.
JENNINGS,
West Wall, Newcastle-on-Tyne. 9743

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } Row's Patents.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5722

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9564
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YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9818
See Full Page Advt., page 63, March 31.

Forgings.
Walter Somers, Limited, HALESOWEN. 7116

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 57. 2402

Taylor & Challen Presses
5196
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement, page 56, March 31.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 600

GRAPHITED OIL. **"OILDAG"** (Reg.) BRAND.
GRAPHITED WATER. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE. **"GREDAG"**
9606
E. G. Acheson Ltd.,
Dept. E., 40, WOOD ST., S.W.1. (Sole Manufacturers.) Works: PLYMOUTH.

Locomotive Traversers
(ELECTRIC).
9662
S. H. HEYWOOD & CO., LTD., REDDISH.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices; 129, Trongate, GLASGOW. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W.1.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9727
See half-page Advertisement page 42, April 14.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

Institute of Physics.

LECTURES ON "PHYSICS IN INDUSTRY."

The First Lecture of this series will be delivered by PROFESSOR ARCHIBALD BARR, D.Sc., F.Inst.P., on Wednesday, April 26th, 1922, at Eight p.m., at the Institution of Civil Engineers, Great George Street, Westminster. The Right Hon. H. A. L. FISHER, Minister for Education, will preside.

F. S. SPIERS,
Secretary.
16, Hanex Street,
W.C. 2. U 5

IN THE HIGH COURT OF JUSTICE
CHANCERY DIVISION,
MR. JUSTICE SARGANT.

IN THE MATTER of TWO LETTERS PATENT Nos. 7206 of 1906 and 13096 of 1906, both granted to HAROLD MALCOLM DUNCAN and FRANK HINMAN PIERPONT and bearing date the 26th March 1906 and the 6th June 1906 respectively
and
IN THE MATTER of THE PATENTS AND DESIGNS ACTS 1907 and 1919.

Notice is Hereby Given that

the Lanston Monotype Corporation Limited, whose registered office is at No. 43, Fetter Lane in the City of London, assignees of the said Letters Patent, has, by Originating Summons dated the 20th day of March 1922 applied that the time within which application under the above-mentioned Acts may be made may be extended and that new Letters Patent may be granted in the place of Letters Patent Nos. 7206 of 1906 and 13096 of 1906 for such term and subject to such restrictions, conditions and provisions as the Court may think fit; and NOTICE IS HEREBY GIVEN that on Tuesday the 23rd day of May 1922 application will be made to the Court that a day may be fixed before which the said summons shall not be in the paper for hearing; and NOTICE IS HEREBY GIVEN that any person desirous of being heard in opposition to the said summons must, at least Seven days before the said 23rd day of May 1922 Lodge notice of such opposition at the Chambers of Mr. Justice Sargant, Room No. 157 Royal Courts of Justice, Strand, London, and serve a copy thereof upon the applicants.

Dated this 12th day of April, 1922.
BRISTOWE, COOKE & CARPMAEL,
1, Copthall Buildings,
London, E.C. 2.
Solicitors for the Applicant, on whom all documents requiring service may be served. T 983

Correspondence Courses for

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Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. F. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—30, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 566

Inst. C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of ENGINEERING.

TENDERS.

BOMBAY BARODA & CENTRAL INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon on Friday, 12th May,

Tenders for the Supply of:—

1. GOODS WAGONS.
2. WHEELS AND AXLES.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 20/- each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.
Offices:
The White Mansion,
91, Petty France,
Westminster, S.W. 1.
19th April, 1922. U 32

EAST INDIAN RAILWAY.

The East Indian Railway Company is prepared to receive

Tenders for the Supply and DELIVERY of WROUGHT IRON

(Billets, flats, rounds and squares).

as per Specification to be seen at the Company's Offices.
Tenders are to be sent to the undersigned, marked "Tender for Wrought Iron," not later than Eleven o'clock a.m., on Wednesday, the 3rd May proximo.
The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.
For each Specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By Order,
G. B. LILLIE,
Secretary.
Nicholas Lane, London, E.C. 4.
19th April, 1922. U 15

SIAMESE STATE RAILWAYS.

NOTICE.

Tenders are Invited for

SUPPLY of RAILS and PERMANENT WAY ACCESSORIES.

Specifications and Drawings may be obtained against payment of £1 from Messrs. C. P. SANDBERG, 40, Grosvenor Gardens, London, S.W. 1.
Sealed Tenders with the inscription "Tender for the Supply of Rails and Permanent Way Accessories B.E. 2468" must be forwarded to the undersigned, at whose office in Bangkok, Siam, they will be received up to Two p.m. on the 31st of July, 1922, at which place and hour the Tenders will be publicly opened and read.
Right is reserved to reject any or all Tenders, and to accept any Tender which, in the opinion of the undersigned, is to the best interests of the Siam State Railways.

Department of State Railways, Bangkok,
25th February, 1922. U 7
(Signed) General PURACHATRA,
Commissioner-General of State Railways.

For Sale by Public Tender.

To close the 2nd day of May, 1922.
The BUSINESS of the BRITISH CARBONIZING CO., LIMITED, Manufacturers of Metallic Grinding Bodies, and Appliances, and Proprietors of the Valuable Patents in connection therewith.
The whole of the undertaking will be sold as a going concern. It is in full working order, and at present has an output of 10 tons per week, which could be considerably increased, there being a constant and increasing demand for the Company's manufactures.
The premises are entirely freehold; the buildings are conveniently arranged and comprise Factory, Tool Room, Store Room, Yard, Dwelling-house with ground floor fitted as Offices.
The premises will be on view as from the 24th April to 1st May, 1922.
Full particulars with Conditions of Sale, Forms of Tender, and permit to view can be obtained on application to Mr. A. LIONEL LANE, Solicitor, or Messrs. DUART-SMITH, BAKER, and PRICE, Accountants, all of Gloucester. T 949

The Corporations of Middlesbrough, Thornaby-on-Tees and Stockton-on-Tees,

having taken over the Undertaking of the Imperial Tramways Company Limited in the three Boroughs, have FOR SALE portions of the LAND, BUILDINGS, MACHINERY, and PLANT which are not required by the Corporations in connection with the running of the Tramway Undertaking subsequent to the transfer.
The particulars are as follows:—
(1.) Buildings utilised by the Imperial Tramway Company for the purpose of generating electricity and consisting of:—
Power house, measuring or containing 335,610 cub. ft.
Boiler house containing 193,031 cub. ft.
Offices containing 21,546 cub. ft.
Smoke Stack of best pressed bricks and lined with fire bricks.
All necessary foundations for the machinery.
A Wharf, 200 ft. long abutting on the River Tees constructed of pitch pine timber and red deal with 336 sq. yds. of slag pitching.
Boundary Walls together with freehold land upon which the buildings are erected and adjacent and incident thereto containing 426 sq. yds. or thereabouts.
The buildings are built of best pressed brick; the Power House being lined with glazed bricks.
The Power Station is equipped with 3 Corliss horizontal, compound condensing engines, direct-coupled to 3 phase, 25 cycle 2500 volt generators, 2 Rotary Converters 25 cycle wound to give 500 to 550 volts on D.C. side, Rotary Converter Booster, Switchboard, Overhead Travelling Crane, Motor-driven Centrifugal Circulating Pump, 3 Babcock and Wilcox Boilers, evaporation 12,000 lbs. with Vickers' Mechanical Stokers, Electric Motor for driving Mechanical Stokers, Green's Economiser, Coal Bunkers, Coal Elevator (fitted with Avery's Automatic Weigher) Electric Grab Crane, Cables, Piping, Electric Lighting equipment and other forms of plant and machinery necessary for a fully equipped Electricity Generating Station.
The whole of the above are situate and adjacent to Bridge Road, Stockton-on-Tees, and abut upon the River Tees a little to the west of the Victoria Bridge which crosses the Tees at or near to that point.
The buildings which were erected about 22 years ago are built in a most substantial manner and are in good order and condition.
The Plant has likewise been kept in first-class running order.
In addition to the above, there is also for sale:—
(2.) Plant and Machinery in the Newport Sub-Station situate in Newport Road in the Borough of Middlesbrough, consisting of:—
3 Rotary Converters, Single-phase Air-cooled Transformers, Centrifugal Fans, Electric Motors, Switchboard, 13 panels, and all necessary cables.
(3.) Also the following plant now at Bridge Road premises, Stockton-on-Tees:—
Weighbridge, Hydraulic Lifting Jack, Axle Tester, Hydraulic Rail Bender, Hydraulic Punching Bar, Wells' Light, Snow Sweeper, Hand Amoulance.
TENDERS ARE INVITED FOR THE PURCHASE OF:—
(1.) The Land, Buildings, Machinery and Plant as described above situate in or near to Bridge Road, Stockton-on-Tees.
(2.) The Plant and Machinery at the Newport Sub-Station.
(3.) The Miscellaneous Plant or alternatively, Tenders, under the head of—1, 2 and/or 3 separately or any two of them.
Particulars and Conditions of Sale and permission to view can be obtained from the undersigned, to either of whom sealed Tenders must be sent no later than May 30th, 1922.
Please mark envelopes "Tenders for Tramway Premises or Plant."
The Corporations give no undertaking to accept either the highest or any other Tender or Tenders that may be sent in.

PRESTON KITCHEN,
Town Clerk and Clerk to the Tramways Committee, Municipal Buildings, Middlesbrough,
THOS. DOWNEY,
Town Clerk and Clerk to the Stockton and Thornaby Joint Tramways Committee.
Borough Hall, Stockton-on-Tees.
6th April, 1922. T 953

Tenders are Invited by

the GOVERNMENT of NEW SOUTH WALES for the CONSTRUCTION of the SUPERSTRUCTURE and SUB-STRUCTURE of a CANTILEVER BRIDGE ACROSS SYDNEY HARBOUR from DAWES POINT to MILSON'S POINT, embracing a main span of 1600 ft. in the clear, centre to centre of main piers, or 2000 ft. centre to centre of anchor piers. The total length of bridge included in tender is 3816 ft., centre to centre of abutments. The deck of the bridge is to include four lines of railway, and a roadway 57 ft. wide, between main trusses; and cantilevered outside the main trusses on the western side, a footway 15 ft. wide, and on the eastern side a motor roadway 18 ft. wide. Copies of specification, including plans, general conditions, and schedule of quantities may be obtained on application to the undersigned.
To give any information required by Tenderers, Mr. J. J. C. BRADFIELD, Chief Engineer, will be in London during June and July, 1922, address care of the undersigned.
Tenders in accordance with the specification must reach the Under Secretary for Public Works, Sydney, not later than 31st October, 1922.

AGENT-GENERAL
FOR NEW SOUTH WALES.
Australia House, Strand, London, W.C. 2.
December, 1921. T 34

PORT OF BRISTOL.

GRAIN HANDLING MACHINERY, NEW GRANARY, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction

and ERECTION on site of GRAIN HANDLING MACHINERY for the New Granary, Royal Edward Dock, Avonmouth. The Machinery consists of elevators and conveyors and includes motors and switchgear for driving the same.
On and after Friday, the 28th April, 1922, copies of the Specification and Contract Drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £3 has been paid. All cheques must be made payable to "The Bristol Docks Committee" and forwarded to the General Manager and Secretary, Dock Office, 19, Queen Square, Bristol. The deposit will be returned to *bona fide* Tenderers after the receipt of the Tender with all the prescribed documents and drawings.
Tenders must be enclosed in a sealed envelope endorsed "Tender for Grain Handling Machinery" and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m. on Tuesday, the 23rd May, 1922.
The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACH,
Engineer.
Engineer's Office,
Avonmouth Docks.
20th April, 1922. T 998

APPOINTMENTS OPEN.

UNIVERSITY COLLEGE OF SWANSEA.

Applications are Invited for

the POST of LECTURER in Civil Engineering. Salary £500 per annum. The appointment will date from October 1, 1922.
Further particulars may be obtained from the undersigned, by whom applications must be received on or before May 13, 1922.

EDWIN DREW,
Registrar.
Singleton Park, Swansea.
April, 1922. T 985

The Egyptian State Railways

HAVE A VACANCY for a DISTRICT LOCO SUPERINTENDENT at a commencing salary of £E540 a year (consolidated pay). Public School education indispensable.
Applicants must have served a time in a railway workshop, or in the workshops of a firm which constructs locos, and in addition must have had some small position involving charge on a Railway, preferably in the running department, for a period of at least one year. Applicants must be unmarried; age must not exceed 30 years.
Forms of application are to be obtained from the office of the INSPECTING ENGINEER, EGYPTIAN AND SUDAN GOVERNMENTS, Queen Anne's Chambers, Westminster, S.W. 1. T 966

TEMPORARY CIVIL ENGINEERS FOR SERVICE IN BURMA.

THE SECRETARY OF STATE FOR INDIA is prepared to receive

Applications for Ten APPOINTMENTS as TEMPORARY CIVIL ENGINEERS for service

under the Government of Burma, on agreements for three or five years, on pay of Rs.700 a month for the first year, rising by annual increments of Rs.100 a month to Rs.1000 a month for the fourth and fifth years. No extension of service beyond the term of the original agreement is contemplated.
Candidates must be British subjects of not less than 20 and not more than 35 years of age, and of good character and sound physique. They must either (1) have obtained a recognized University degree or other distinction in Civil Engineering, or (2) have obtained the Associate Membership of the Institution of Civil Engineers, or (3) produce evidence that they are otherwise eligible under the regulations. They must, in addition, have had not less than two years' practical experience on works preferably as Assistants to Borough or Municipal Engineers in this country.
Applications from candidates much reach the India Office not later than 1st May. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, PUBLIC WORKS DEPARTMENT, India Office, Whitehall, London, S.W. 1.

India Office,
17th March, 1922. T 846

Assistant General Manager

WANTED by Shipbuilders and Engineers in China. Aged about 30. Reply, detailing experience and qualifications for the position; also salary wanted for three years' engagement.—Address, U 13, Offices of ENGINEERING.

COUNTY BOROUGH OF GREAT YARMOUTH.

TRAMWAYS MANAGER.

Applications are Invited for

the POST of TRAMWAYS MANAGER (Engineer preferred), to take entire charge of the Corporation's Tramway Undertaking, outside the Power Station, with the exception of the maintenance and control of the overhead Electrical Equipment. Salary £400 per annum. Canvassing is prohibited.
Applications, which should state experience in permanent way work, and be accompanied by a copy of three testimonials, must reach me not later than Noon on Tuesday, 2nd May.

W. EDGAR STEPHENS,
Town Clerk.
Town Hall,
Great Yarmouth,
20th April, 1922. U 16

Power Station Superintendent

REQUIRED to take charge of a large Power Station in South Wales, supplying three-phase power and equipped with high pressure steam turbine plant.—Address, stating qualifications, age, salary required, and send copies of testimonials, T 956, Offices of ENGINEERING.

Engineer Wanted; one used

to erecting machinery and well conversant with electric plant.—Address particulars, T 999, Offices of ENGINEERING.

Wanted, in Liverpool, Energetic Engineer,

already representing Engineers, to take up Agency for well-known firm's productions. Minimum commission guaranteed.—Address, T 990, Offices of ENGINEERING.

Representative Wanted for

South West England, working from Bristol preferably. Must be trained Engineer and have sales experience in Gas and Oil Engines, Gas Plants and Pumps.—Write, stating experience, salary required, etc., THE CAMPBELL GAS ENGINE Co., LTD., Kingston, Halifax. T 955

Draughtsman, First-class Man

with knowledge of ship construction and design WANTED for one or two years' engagement in South America; preference to a single man. State age, experience and salary required.—Address, T 976, Offices of ENGINEERING.

Leading Draughtsman

REQUIRED with first-class experience of Horizontal Airless Injection Oil Engines. State experience, age, salary, and when at liberty.—Address, T 994, Offices of ENGINEERING.

Draughtsman Wanted, with

good experience in Petrol and Steam Commercial Vehicles. State full particulars and salary expected.—Address, COMBUSTION, WM. PORTEOUS AND CO., Advertising Agents, Glasgow. T 996

Control Apparatus Designer.—

EXPERIENCED MAN REQUIRED, capable of working out designs of Traction Control Apparatus from a Specification with scheme of connections; experience of modern locomotive control gear essential; knowledge of manufacturing methods an advantage; must be a good disciplinarian. State age, technical training, experience, and salary required.—Address, T 973, Offices of ENGINEERING.

Wanted, by a Port Authority,

a fully qualified CHIEF DRAUGHTSMAN in the Chief Engineer's Office, age about 35-40 years. Salary £700 per annum. Applicants should state fully their experience in designing and construction of docks, buildings, constructional steel-work, bridges, reinforced concrete, surveying and quantity surveying; also if disengaged or how soon they could take up duty. Applicants should be competent to take control of drawing office staff, and should state fully their experience, accompanied by references.—Address, U 8, Offices of ENGINEERING.

Required for Service in the

Carriage and Wagon Department of the BOMBAY BARODA AND CENTRAL INDIA RAILWAY—

ONE ASSISTANT FOUNDRY FOREMAN

who must have had experience as a Furnace Operator, and be acquainted with the Properzi Steel Process. A knowledge of steel mixtures is essential. Preference will be given to a man who in addition to the above qualifications has had experience as a Moulder. He should be capable of taking charge of a small Steel Foundry, and must be thoroughly reliable and steady. Age should not exceed 35 years.
SALARY: Rs. 300 rising by annual increments to Rs. 400 per calendar month.
TERMS: A three years' agreement in the first instance, second-class free passage to India and home again on satisfactory termination of service.
The selected candidate will be required to pass a strict medical examination by the Company's Consulting Physician before final appointment.
Letters of application, giving particulars of applicants' general and technical education, and showing in chronological order (with dates) where and how they have been employed from time to time and also stating age, and whether married or single, should be addressed to the undersigned not later than the 5th May, 1922.
Copies (not originals) of testimonials, etc., should be sent.

S. G. S. YOUNG,
Secretary.
Offices: The White Mansion,
91, Petty France, Westminster, S.W. 1.
21st April, 1922. U 24

Articled Pupil.—A Civil

Engineer has VACANCY for well-educated young gentleman as PUPIL. Good practical and theoretical training. Interesting works in hand. Premium required.—Address, T 995, Offices of ENGINEERING.

MASS PRODUCTION IN GEAR-CUTTING.

By JOSEPH HORNER.

(*Concluded from Page 445.*)

Mass production extends to the preparation of the blanks for the gear-cutting machines, which in all the smaller sizes are drop-forged. The turning is not done in the common lathes, using a single tool, but in lathes fitted with batteries of tools for multiple cutting, and in automatic turning machines. Tools operate simultaneously, or in rapid succession. They are mounted and set in specially-designed posts, and remain fixed until they have to be reground. The chucks too are designed to hold one class of gear, of one size, or not differing much in dimensions. And the operations on one blank are commonly divided between two machines, one boring and facing bosses, the other turning with the work held on an arbor. This is more nearly accurate than boring and turning on one machine, with the additional advantage that the back and front sides of a rim can be turned without re-chucking, and often that two gear blanks can be mounted on one arbor, and tooled simultaneously. Tools are commonly mounted so that when roughing and finishing cuts are required, the latter follows immediately in the track of the first. Tool rests are mounted at front and rear, each with its suitable battery of tools. In cases like this an operator can attend to two machines. Another method of dealing with blanks is in the turret lathe. The work is generally divided between first and second operations, when the rear side cannot be tooled otherwise. The blanks are held in chucks, or on arbors, depending on shapes, and proportions. The batteries of tools held in turret and cross slide secure rapidity of output. Yet in some cases it is more economical to prepare work on the turret lathe, to be completed more expeditiously in the automatic lathe. This subject of the division of operations into first and second, commonly performed on different machines, often of diverse designs, is one that has a paramount interest in advanced machine shops.

Inseparable from mass production are the numerous fixtures designed for holding blanks while the teeth are being cut. These have become indispensable if a maximum output is to be secured, because the common methods of mounting on arbors do not afford sufficient support against heavy cutting, and especially so when the method is that of hobbing, or generating with a rack. In the fixtures, the blanks are supported all round the rim close to the roots of the teeth, and clamped firmly. When practicable a fixture is made to receive more than one blank. Rapidity of gripping is secured by making slot holes in the clamping plates, which can be moved around the bolts and so slipped off the nuts without running these off the bolts. Bevel wheel rings are held with large clamp plates. Blanks with bores are centred on arbors. Those with stems are secured in bushed fixtures. Cluster gears solid with their shafts are held similarly.

With extension of mass production, increased care becomes necessary in determining, and standardising the methods of hardening and toughening that are employed with all those used in automobile construction, and in most of the gear boxes fitted to the best machine tools. The practice is not simple, nor uniform. The different brands of steel used in the straight carbon, and in the very numerous alloy groups, require different treatments and each consignment of steel may require some modifications. The question of case-hardening carbon steels, and of uniform heat treatment to confer great tensile strength and toughness arises. The shapes of gears, their masses, the presence of long bosses, solid, or cored with thin walls, affect results. Tests are only reliable when made on shapes similar to those under treatment. For general procedure, the instructions of the steel makers given with different alloys, and various grades, can be relied on.

If strength and toughness are most desired, some of the alloy steels, uniformly heat-treated, are employed. But if surface hardness obtained by case-hardening, then the low carbon steels are preferred. These also cost less to machine than the alloy tempering steels do, a fact which must enter into calculation in mass production. The price of the latter is also higher. Case-hardening steels have the advantage that parts can be left soft, which is often desirable. Shrinkage strains occur when unequal masses, such as small and large gears, are made in one piece.

The practice is reflected in the very numerous designs of furnaces now employed for carburising, and for heat treatments, furnaces in which the temperatures are easily regulated, and built for different services. Oil systems, somewhat elaborate, are installed for quenching, including storage and cooling tanks, and systems of piping. The heating of gears for equal temper heat-treatment generally includes double treatment, reheating with higher and lower temperatures that vary with the chemical compositions of the steels. Those in commonest use are straight carbon, nickel, chrome nickel and chrome vanadium, each in diverse grades with high, medium, and low percentages of the chief alloying element.

The hardening of gears is causing the growth of the practice of subsequent grinding. Even though distortions may be slight, they are sufficient to prevent the smooth and quiet running which are desirable. Grinding with formed wheels is not to be considered, since they are inconsistent with the degree of accuracy obtained by generation. The only way is to use disc wheels, set at the angle of pressure of the teeth, and against which the gear is rolled. The wheel faces in contact with the teeth represent the flanks of the basic rack tooth. A difficulty arises from the wear of the wheels, for which some compensation must be made.

In the Maag grinding machine, the discs are not made with flat faces, but are saucer-shaped, the edges operating. This is considered preferable to the use of wheels with true planes which might wear unevenly. A corrective device is included in the form of two diamonds mounted on pivoted arms which are fed with an electric contact in steps of 0·001 mm. By this means, soft, quick cutting wheels can be employed. Two grinding discs are used, cutting on each opposed tooth face, except in fine pitches, when one operates on the next flank, or on the next flank but one. The grinding discs are disposed at the angle of the flanks of a standard rack tooth.

The grinding of hardened worms is, if possible, more necessary than that of other forms of gears. In the machine by Messrs. David Brown, a cupped wheel grinds one side of the threads first, after which the worm is reversed on its centres and the other side is ground. The grinding wheel is set to the helix angle in a universal head, while the worm is travelled in a longitudinal direction, and slowly rotated so that it travels spirally in front of the wheel. The motion passes through a gear box, but the return stroke is rapid, during which the worm is indexed for the next cut. The wheel can be slid horizontally towards, or away from, the worm that is being ground. At the moment of reversal the grinding head is rapidly withdrawn from the work, and at the end of the return stroke it approaches the worm thread ready for the next cut. The wheel carrier can be swivelled about a horizontal axis, and the grinding head body about a vertical axis, so permitting the wheel to be set in relation to the work. The wheel carrier is bolted to an annular face, that forms the front part of the grinding head casting. Its outer circumference is graduated in degrees for correct angular adjustment. The angle to which the wheel spindle is swivelled must correspond with the lead angle of the worm being ground. The carrier is swung to one side or the other to suit the lead of the worm being ground, right or left hand. The work head contains gearing for the rotation, and indexing of the worm, and the speed at which the worm thread travels across the face of the wheel is varied through the change speed gear-box.

When gears are hardened distortion of the bores occurs, and it becomes necessary to correct these, which can only be done by grinding. It is not economical to perform this work on the plain, or universal, grinding machines, in which the spindle must overhang from the wheel stand. Machines are built specially for this work in which the grinding spindle is mounted directly on the main table, where it is rigidly supported without overhang. All necessary provisions are included for variations in work speeds to suit holes of different diameters, through a quick-change gear-box, and different rates of table travel to correspond with variable speeds, with automatic reversal. Cross feed is included, and hand movements. The head can be swivelled up to 45 deg. in each direction for the grinding of tapered bores.

The chuck designs of these machines embody provisions for centring by the teeth in order to ensure the concentricity of the ground bores. The chucks are of the draw-in collet type, to secure rapidity of grip. Adjustable jaws are used to suit different classes of gears, and to embody alternative methods, but the tapered collet fitting closes them in simultaneously and instantly. The jaws may grip the outsides—the points of the teeth which is not considered the best. Another method uses rolls to make contact between adjacent teeth on the pitch line at three equidistant locations round the circle. The third method makes contact with tongue pieces on the jaws at the roots of the teeth in three positions.

An aspect of mass production is the specialised manufacture of unit gears in enclosed casings. These are common in automobile manufacture, in turbine, and motor driven reductions, and in the later designs of machine tools. Made in quantities by firms who give attention largely to these designs, they are ready for installation in the class of vehicles, or groups of machines or mechanisms for which their services are required, to be connected up at once. They include spurs, bevels, single and double helicals, and worm gears, the last two for reductions larger than those which are practicable with single reduction spur gears. The shafts, often splined, are like the gears, heat treated. They run in ball bearings, and dip, or splash, or forced lubrication is adopted, depending on the nature of the service.

Since a high degree of accuracy, with interchangeability are essential facts in mass production, the testing of finished gears has been advancing along several lines. Each class of gear requires some different method, and the checking of other elements than the teeth, which alone were formerly gauged, with the result that several appliances and machines are now enlisted in the work of testing. In the last developments errors are magnified, and record diagrams are taken of inaccuracies.

1,200-H.P. ELECTRIC LOCOMOTIVES FOR THE METROPOLITAN RAILWAY.

(*Concluded from page 412.*)

THE control gear of the locomotive is arranged so that the four motors operate in pairs, each pair being provided with a separate equipment, arranged to give series, parallel control. The equipment is of the Metropolitan-Vickers all-electric type, the contactors being operated by solenoids energised from the line voltage, and controlled through train lines connecting them to the master controllers in the driver's cabs. The main current from the positive shoes passes through the shoe fuses, junction boxes and main isolating switch to a positive bus bar fixed on a switch panel in the body of the locomotive. The negative shoes are similarly connected to a negative bus bar on a panel placed at the opposite end of the locomotive. These connections will be followed from the diagrams given in Figs. 23A, 23B, and 24, on pages 478 and 479. It will be understood that Fig. 23B is a continuation of Fig. 23A, it not being possible to illustrate the whole of the connections in a diagram within the limits of a single page. The lines XX in the two figures correspond. The diagram shown in Fig. 24 is a simplification of the main diagram, and shows the main connections only. For the purpose of following through our general description of the control arrangement, Fig. 24 will perhaps be found the more useful, but for those who wish to study the details of the equipment, Figs. 23A and 23B are, of course, essential.

Two separate circuits, one through each pair of motors, are taken from the switchboards through double-pole switches, which act as isolators for their respective equipments. These circuits are

protected by positive and negative fuses, and also by solenoid operated circuit-breakers, fitted with automatic overload series trip coils. The breakers are also provided with a separate electrical trip, controlled by the driver. These double-pole switches, fuses and circuit-breakers are shown at either end of the diagram given in Fig. 24. The reversers for controlling the direction of rotation of the motors, and so the direction of motion of the train are connected in the main motor fields, and consist of driver-type switches, operated by solenoids acting on a rocker arm on the drum shaft. Automatic acceleration is provided by means of a combined current and time-controlled accelerating relay. This relay operates contacts in the control circuits, and governs the sequence of closing of the contactors. The relay is designed so that its control contacts never break a circuit, the action being obtained on making the circuit; this method avoids any danger of bad contacts through burning. The motor current is controlled by solenoid operated contactor switches, the solenoids of which are energised from the line through a master controller. Interlock contacts are provided on the contactors to ensure that they close in the proper sequence.

As already explained, the locomotives are provided with multi-core train lines and couplers, so that more than one locomotive may be coupled and driven from any master controller. In addition, the locomotives are provided with main power bus lines, which are normally connected to the power bus lines on the rolling stock they have to haul, certain coaches, as before mentioned, being provided with collecting shoes. The connections for these train lines are clearly shown in the diagram. The supply to the control circuits is taken through a control switch to the master controller, and from thence through a multi-point control cut-out switch to the equipment. The cut-out switch is provided for the purpose of isolating the control circuits of its own two-motor equipment, while permitting the other two motors still to be operated from the master controller. The main handle of the master controller has four operating positions. The first position, usually called the switching position, gives series connection to the motors with all resistance in circuit, while the second brings the automatic relay into operation, and the resistance gradually cuts out, step by step, until full series is reached. The third position connects the motors in parallel with all resistance in circuit, the "bridge" connection being used in passing from series to parallel. The fourth position brings the automatic relay into operation again, cutting out the resistance, step by step, until full power is obtained.

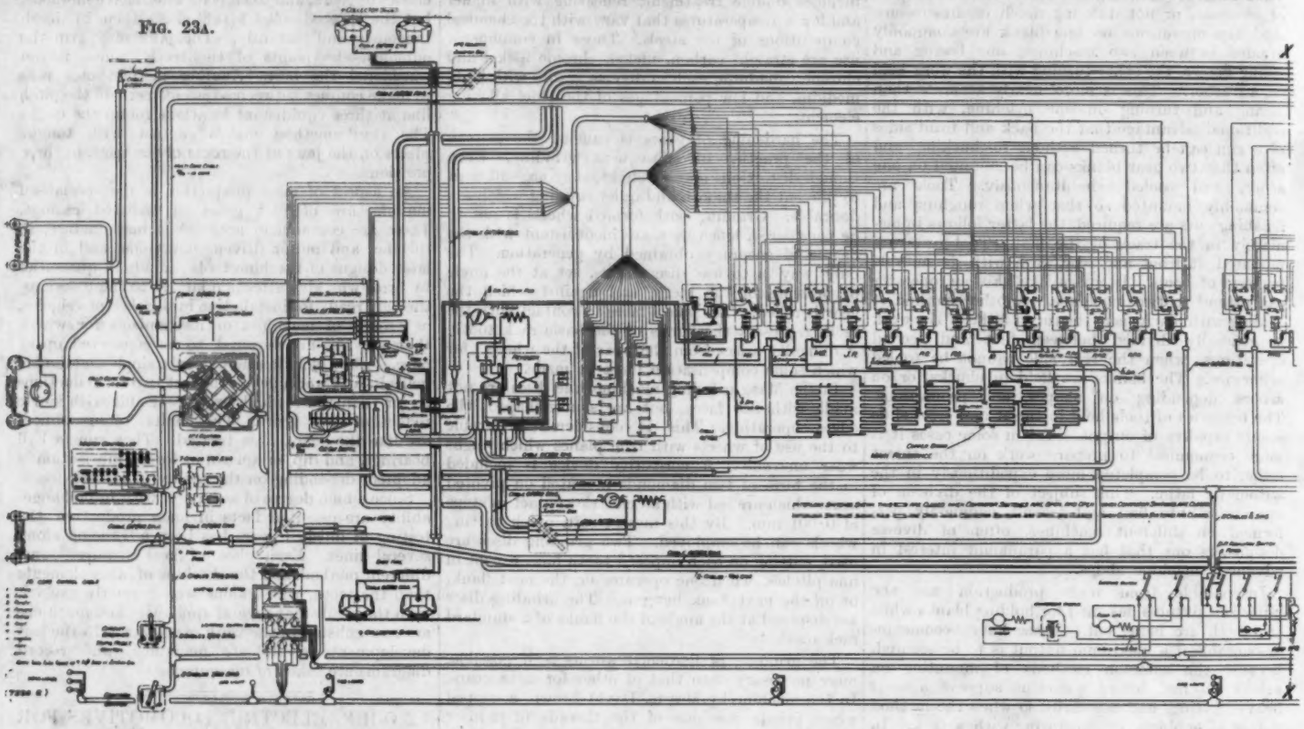
In the event of the driver removing his hand from the master controlling handle the latter moves upward automatically, cutting off the control current and simultaneously applying the emergency brakes through a special valve in the controller working in conjunction with a relay valve. For coasting purposes, and when making ordinary service stops, the driver moves the controller handle to the off position, but keeps his hand on the handle, thus preventing the interruption of current, and the application of the emergency brakes. The control is so arranged that it is not necessary to pause on each notch of the master controller until the corresponding motor connections are completed. The handle may be moved directly to either the series or parallel positions when the control will automatically notch-up, step by step, until a position is reached corresponding to the particular notch on which the handle is placed. If it is desired to obtain a slower rate of acceleration, the master controller handle should be moved to the second or full series position, and immediately returned to the switching position. Each time this operation is repeated a step of resistance is cut-out of circuit, providing that the current taken by the motor is not in excess of the current for which the automatic relay is set. This action is repeated until the full series position is reached. By repeating the operation on the parallel notches, step by step, acceleration can then be obtained until full parallel is reached. This arrangement permits the driver to increase the time of acceleration, while it adequately protects the equipment by means of the automatic relay preventing the next step from being taken until the current has fallen at least to the predetermined limit.

Having now dealt with the control equipment in general terms, and described the method of operation we may refer to the main items of that equipment in rather more detail. This closer consideration will facilitate the following through of the diagrams given in Figs. 23A, 23B, and 24, and will give an opportunity of calling attention to any points of special interest in the apparatus. Taking the main circuit as before, the first items to be considered are the collector shoes. These do not require much comment. As before pointed out, and as shown on the diagrams, there are four positive shoes. They are mounted on teak beams, bolted to lugs cast on the axle boxes, each beam carrying two shoes in parallel. Contact pressure on the rails is obtained by gravity. The four negative shoes, of similar type, are fixed on shoe beams attached to brackets bolted to the motor frames. The circuit from the positive collectors after passing through the shoe fuses, an isolating switch and the main equipment fuses, connects to the main circuit-breaker. The main equipment fuse is added as an additional safeguard against excessive overload and short circuits. It is of copper strip, enclosed in an arc-resisting insulated case, and provided with a magnetic blow-out.

The main circuit-breaker is mounted alongside the contactors on the iron framework situated along the centre line of the locomotive. It is illustrated in Figs. 25 and 26, on page 480. As will be seen from Fig. 25, it is provided with arcing horns carried in an arc shield. The main contact is made by a laminated copper brush, and heavy contact tips are fitted for the final break. A magnetic blow-out, the coil of which can be seen in Fig. 25, forces the arc along the horns. The breaker is closed by energising its main operating solenoid, but when it is closed it is mechanically held in position by a trigger. On overload, the main series coil, which is shown to the right in Fig. 26, exerts a pull on a lever which releases the trigger. A trip coil is also fitted which can be energised by operating a trip switch in the driver's cabin. This allows a driver to trip all circuit breakers on a train at any time if found necessary.

From the circuit breakers the current passes through the various contactor switches to the motors, either direct or through the resistances as may be necessary. The connections may be followed from the diagrams. Each contactor switch is a separate unit of the type illustrated in Figs. 27 and 28, on page 480, and 13 such units make up one equipment as shown in Fig. 23A and 23B. There are two such groups of 13 contactors, each with its circuit breaker and fuses. They are mounted on the framework in the centre of the locomotive. The individual contactors are suspended from the horizontal members of the framework by means of insulated steel tubes and pressed steel brackets to which the contactors are bolted. Any contactor may easily be removed by taking out the bolts and sliding it forward. The contactors are solenoid-operated, and the jaws are

FIG. 23A.



provided with a magnetic blow-out as shown in Fig. 28, on page 480. The jaws are provided with arcing tips which may be easily and cheaply renewed, while as the contactor closes, a knuckling spring causes the arcing tips to roll over one another with a rubbing action which serves to flatten out any irregularities or grit which may exist between the contact faces. The removal of two screws permits the removal of one of the contact jaws with arcing tips, and this can be done without disturbing any other portion of the switch while it remains in its position in the group.

The interlock switches are mounted at the back of the contactor switches, as shown in Fig. 27. These interlock switches, or contacts, are connected in circuit with the various operating coils in such a way that the contactor switches can operate only in a definite sequence. In the rare event of failure of any contactor to operate properly, the successive circuits will not be made. The interlocks are mounted on insulated steel bars and are operated from the contactor solenoid mechanism. This ensures a definite position of the interlocking contact corresponding with a definite position of the contactor. The interlocks may easily be withdrawn or renewed when necessary. The main resistances, in connection with which the contactors operate are of the cast-iron grid type, the grids being suspended at three points from insulated steel bars. There are nine resistance frames for each two-motor equipment.

The reverser which controls the direction of rotation of the motors is illustrated in Figs. 29 and 30 on page 481. The apparatus is of the drum type, and is operated by a solenoid acting on a rocker arm on the drum shaft. The main reversing drum is shown in Fig. 29, while the interlock drum with its fingers, arc shield and blow-out coil, which are carried at the back of the main drum, are shown in Fig. 31. The connections of the main and interlock drums are detailed in Figs. 23A and 23B. The main drum castings are clamped to a mica insulated shaft which is arranged to be partially rotated by the operating solenoids. The plungers of the two solenoids are connected by links and levers in such a way that a partial rotation of the drum in either direction is obtained by energising one or other of the solenoids. The operating circuits for these solenoid coils are so interlocked that when a reverser throws-over there is no current passing through its main drum fingers, which prevents the possibility of arcing taking place on the drum. The main fingers are fitted with renewable tips and finger springs, and have heavy copper shunts from the tips to the terminals.

The automatic acceleration of the train is controlled by a current-limiting relay which is illustrated in Fig. 31 on page 481. This contains a series coil which is connected on the earth side of the motors. The connections are shown in Figs. 23A and 23B. The relay essentially consists of a piece of apparatus having a heavy strap-wound series coil and two fine wire coils which have a common magnetic circuit. The fine wire coils are connected in the control circuit in such a way that the current necessary to operate the contactors passes through one or other of them, and then through a contact attached to plungers in the fine wire coil. The current can only flow through the contact of the coil, which is de-energised, and the opening of the control circuit does not take place on the relay, but on the contactor interlocks, so that no arcing occurs on the relay contact. When the circuit is opened the fine wire coil is de-energised and the contact attached to its plunger drops or makes a connection which closes an operating circuit and energises the other fine wire coil. The plunger of the latter then opens its contact and prevents a further operating circuit being made until it is de-energised again. This action may, however, be interfered with by the series coil. When a fine coil wire is de-energised its plunger may still be held up by the magnetic flux due to the current passing in the series coil, and it will only commence to drop when the motor current passing through the series coil falls to a pre-determined value for which the relay has been adjusted. In addition to the current limitation control, the plungers are further controlled by dash-pots having a definite time lag. This arrangement is added so that the acceleration of a light locomotive, or a light train, shall not become unduly rapid.

The control of the motors by means of the contactors and other apparatus is effected by the master controller through an auxiliary circuit which energises the operating solenoids. The controller, which is illustrated in Fig. 32 on page 481, is connected to the line through a control switch and fuse, by means of which the driver can cut-off the control current supply to the train. The master controller is of the drum type and is provided with main and reverse handles. A "dead man" feature is embodied in the main handle, which is arranged so that it is necessary for the driver to keep it pressed down to keep the power on. If the handle is released it moves upwards under the action of a spring, and mechanically releases a drum switch which flies back to the off position and interrupts the control current supply, with the result that the contactor operating coils are de-energised and the main power circuit is thereby broken. At the same time air is admitted to the train pipe by means of a pilot valve on the controller operating in conjunction

FIG. 23B.

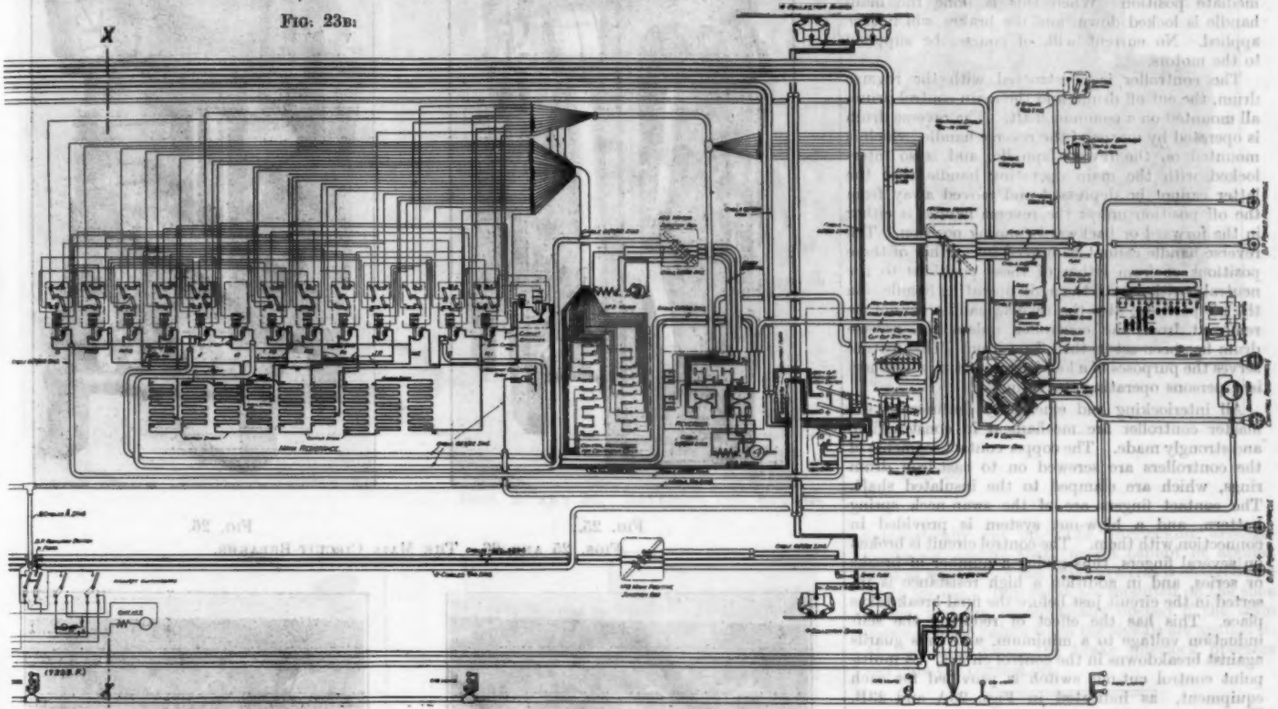
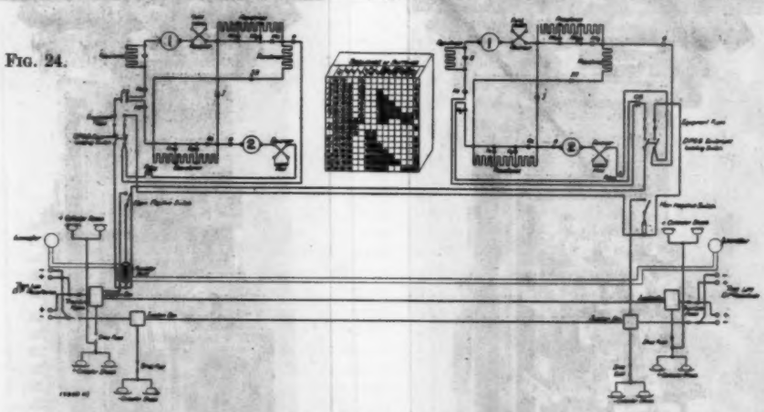


FIG. 24.



with a relay valve, so that the brakes are automatically applied.

Whenever the handle has been allowed to move upwards, with consequent cutting-off of current and application of brakes, it is necessary to return the handle to the off position before the brakes can be released or the train started again. This is a valuable feature for preventing the mishandling of the train. Under certain conditions, when, for instance, the driver is looking for a signal on the opposite side of his cab, it is necessary to prevent the brakes being applied when he releases the handle of the controller. He can arrange this by bringing the main handle back to the off position, and then putting the reverse handle in its intermediate position. When this is done the main handle is locked down, and the brakes will not be applied. No current will, of course, be supplied to the motors.

The controller is constructed with the reverse drum, the cut-off drum, and the main control drum, all mounted on a common shaft. The reverse drum is operated by means of the reverse handle, which is mounted on the reverse spindle, and is so interlocked with the main operating handle that the latter cannot be depressed and moved away from the off position unless the reverse handle is either in the forward or backward running position. The reverse handle cannot be moved into either of these positions or from either of these positions to the neutral position until the main operating handle is in the off position, also the reverse handle cannot be removed from the controller unless the reverse drum has been set in the off position. This feature serves the purposes of a key for preventing unauthorised persons operating the train.

All interlocking and emergency features of the master controller are mechanical in construction, and strongly made. The copper contact segments of the controllers are screwed on to cast-iron drum rings, which are clamped to the insulated shaft. The contact fingers are of the swan-neck spring pattern, and a blow-out system is provided in connection with them. The control circuit is broken on several fingers, thus giving a number of breaks or series, and in addition a high resistance is inserted in the circuit just before the final break takes place. This has the effect of reducing the self-induction voltage to a minimum, and thus guards against breakdowns in the control circuit. A multipoint control cut-out switch is provided for each equipment, as indicated in Figs. 23A and 23B. This switch enables either of the control circuit equipments to be cut out of circuit while the remaining group is operated from the master controller in the usual way. Another auxiliary switch provided in the driver's compartment is arranged to open and close the circuit breakers on the locomotive. The handle of this switch remains normally in the neutral position, and can be pushed over either to the trip or reset positions as desired. When it is released it returns to the neutral position.

The multi-core control line, which is run through the locomotive so that the switch groups may be operated from one master controller, can be carried between locomotives for multiple unit operations, the connection being made by multi-core jumpers. This line is not carried through the train itself, as there are no motor coaches, but, as pointed out earlier, a power bus line is carried through the train to ensure continuity of current supply from shoes fixed to some of the coaches. There is an auxiliary power circuit for supplying energy to the compressor and exhauster motors, and for lighting. It is fed from the main power supply on to an auxiliary switchboard, the connections of which are indicated in Figs. 23A and 23B. The compressor has a capacity of about 38 cubic feet displacement per minute, and is driven by an 8 h.p. motor. Its operation is controlled by an automatic governor switch, which throws it into circuit, and cuts it off in terms of the reservoir pressure.

There are two exhausters. One of these runs slowly when the locomotive is in service, and keeps the train vacuum pipe at the correct vacuum against any air leak there may be in the system. The second exhauster is switched into circuit when the driver wishes to release the brakes quickly. This machine runs at a high speed, and corresponds

ELECTRIC LOCOMOTIVE; METROPOLITAN RAILWAY.

MR. CHARLES JONES, M.INST.C.E., CHIEF MECHANICAL AND ELECTRICAL ENGINEER.

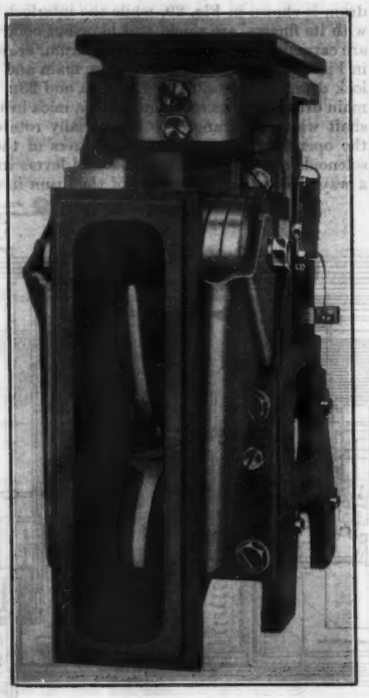


FIG. 25.

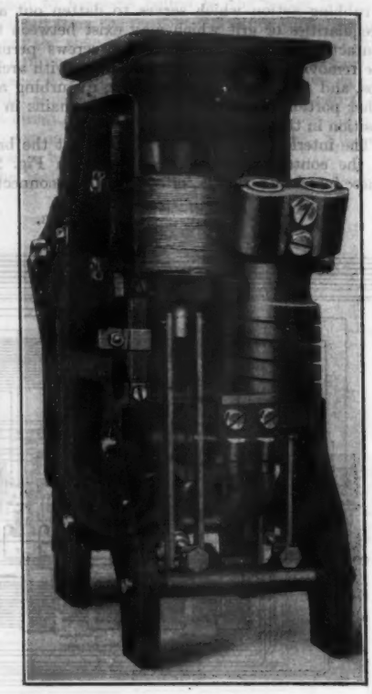


FIG. 26.

FIGS. 25 AND 26. THE MAIN CIRCUIT-BREAKER.

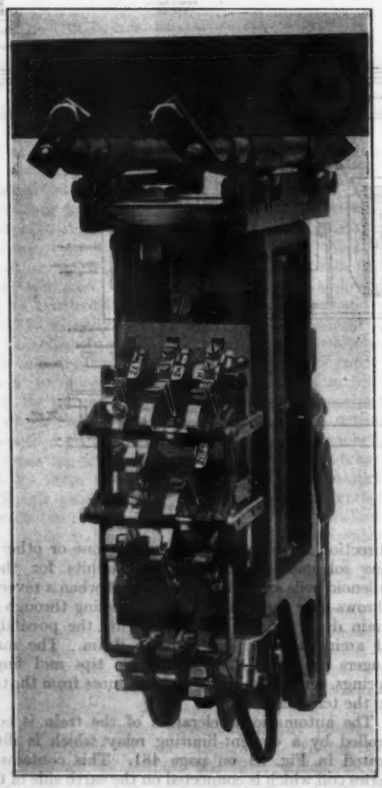


FIG. 27.

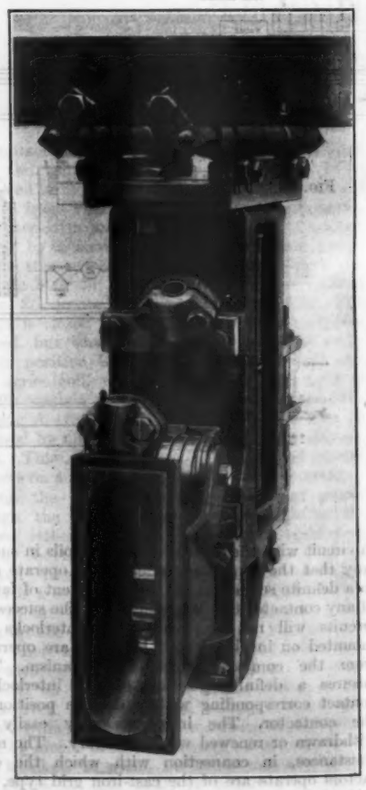


FIG. 28.

FIGS. 27 AND 28. CONTACTOR SWITCH.

1,200-H.P. ELECTRIC LOCOMOTIVE FOR THE METROPOLITAN RAILWAY.

MR. CHARLES JONES, M.INST.C.E., M.I.E.E., CHIEF MECHANICAL AND ELECTRICAL ENGINEER.

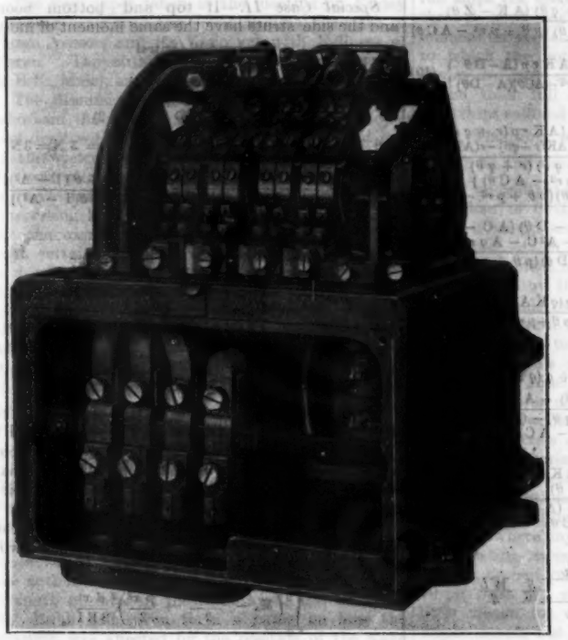


FIG. 29

FIG. 30.

FIGS. 29 AND 30. REVERSER FOR MOTORS.

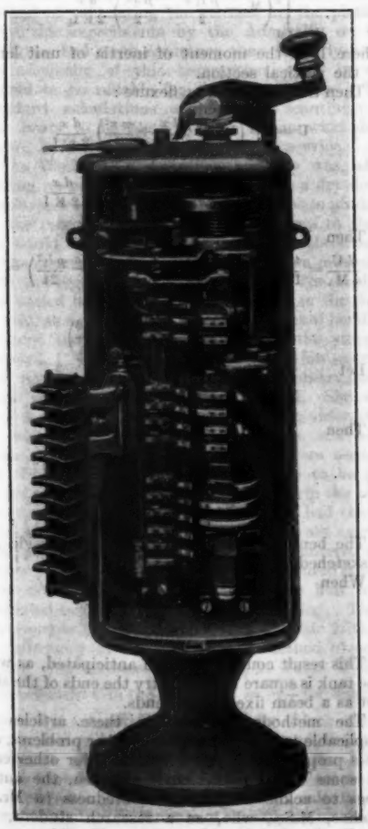


FIG. 32. MASTER CONTROLLER.

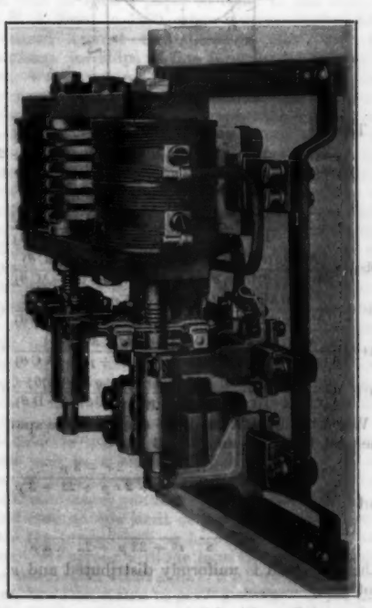


FIG. 31. AUTOMATIC ACCELERATING RELAY.

to the large ejector on the vacuum brake system of a steam locomotive. The motor for the first exhauster is arranged to run at two speeds, the higher speed being obtained by shunting the field. This higher speed puts it within the power of the driver to decrease the time required for releasing the brakes. Automatic interlock switches are provided in both the air and vacuum brake systems, so that it is impossible to apply current to the main motors until the brakes are released. Similarly, should the brakes be applied with power on, the control is automatically cut off. The interlocking arrangements also ensure that current cannot be applied until at least one of the brake systems is charged and ready for use. Trip cocks are mounted on the shoe beams, and are automatically opened if the train passes definite points when the signals are against it. At the same time, the brake interlock operates and cuts the current off.

THE NEW RUSSIAN PRODUCT "MARTENSITE."—The journal of the present Soviet Government of Russia, *Russian Information and Review*, published in London, gives, under the title "Coal and Iron Output in the Urals," besides the production of pig-iron and rolled steel in October, November and December of last year, the production of "Martensite" for those same months, namely, 1,764 tons, 4,832 tons and 10,027 tons respectively. The journal probably means "Siemens-Martin steel" ingots, unless the product referred to be named after a Russian Mr. Martens, in which case it would be desirable to alter its name, to prevent its being mistaken for a certain transition form in metallography.

ZIRCONIUM.—Zirconium ores are not common, but zircon deposits are found in many placer deposits derived from disintegration of granitic and pegmatic rocks. The chief ores are zircon, $ZrSiO_4$, with 67 per cent. of ZrO_2, and baddeleyite ZrO_2 with up to 96·5 per cent. of the oxide; the latter occurs mainly in Sao Paolo, Brazil. Zirkite is a trade name for oxidic zirconium ores. The literature on this metal and its compounds has considerably grown of late, and in Bulletin 186 of the United States Bureau of Mines, J. W. Marden and M. N. Rich, describing their investigations (conducted partly at the Golden station in California) of the ore treatment and the attempts to isolate the pure metal, give a long literature list. The ores are fused with caustic soda, soda ash or nitre cake, or treated with sulphuric acid, and the compounds are purified by crystallisation. The metal can be isolated by the thermit reaction; but the metal does not separate well from the slag, and it is best to fuse the double fluoride with aluminium. This reaction only gives a black velvety powder of a metal at 98 per cent., containing oxide; nitride may also be formed, and the little iron and silicon in commercial pure aluminium disturb the reaction. Even fusion in an Arsem electric vacuum furnace would not yield a compact metal, except in a hydrogen atmosphere at reduced pressure. The white metal then obtained resists corrosion much better than the amorphous metal and alloys with other metals. Ferro-zirconium was said to have been used in Germany during the war for armour plating and for tool steel. Marden and Rich found all the alloys brittle and hard; they may be made by the thermit process or in the arc furnace, from zirkite, powdered iron and fluorspar.

STATICALLY INDETERMINATE AND NON-ARTICULATED STRUCTURES.

By Professor F. C. LEA, D.Sc., M.Inst.C.E., M.Inst.Mech.E., M.I.M., A.R.C.S., Wh.Sc.

(*Concluded from page* 404.)

Summary.

$$\begin{cases} M_{41}.(2r+2p)+M_{14}.r+M_{32}=0 \quad . \quad . \quad (1)\\ M_{41}.r+M_{14}(2r+2)1+M_{23}=-(N+2N_1) \quad (2)\\ M_{41}.p \quad +M_{32}(2q+2p)+M_{23}.q=0 \quad (3)\\ M_{14}+M_{32}.q \quad +M_{23}(2q+2)=-(2N+N_1) \quad (4)\end{cases}$$

From these equations two couples at the corners of the frame can be found.

Let

$$(2r+2p)=A \qquad (2q+2p)=C \qquad -(N+2N_1)=K$$
$$(2r+2)=B \qquad (2q+2)=D \qquad -(2N+N_1)=Z$$

Then

$$\begin{cases} A\,M_{41}+r\,M_{14}+M_{32} \quad =0 \quad . \quad . \quad . \quad (1)\\ r\,M_{41}+B\,M_{14} \quad +M_{23}=K \quad . \quad . \quad . \quad (2)\\ p\,M_{41} \quad +C\,M_{32}+q\,M_{23}=0 \quad . \quad . \quad . \quad (3)\\ M_{14}+q\,M_{32}+D\,M_{23}=Z \quad . \quad . \quad . \quad (4)\end{cases}$$

The solution of these four equations is given by the following determinants :

	Denominator.				Numerator.				
M_{41}	A	r	1	.	.	r	1	.	(1)
	r	B	.	1	K	B	.	1	
	p	.	C	q	.	.	C	q	
	.	q	D		Z	1	q	D	
M_{14}	A	r	1	.	A	.	1	.	(2)
	r	B	.	1	r	K	.	1	
	p	.	C	q	p	.	C	q	
	.	q	D		.	Z	q	D	
M_{32}	A	r	1	.	A	r	.	.	.
	r	B	.	1	q	B	K	1	
	p	.	C	q	r	.	.	q	
	.	q	D		.	1	Z	D	
M_{23}	A	r	1	.	A	r	1	.	
	r	B	.	1	r	B	.	K	
	p	.	C	q	p	.	C	.	
	.	q	D		.	1	q	Z	

Or, solving directly :—

From (1) and (2) :

$$M_{14}(BA-r^2)-r\,M_{32}+A\,M_{23}=AK \quad . \quad . \quad (5)$$

From (4) :

$$M_{14}(BA-r^2)+q(BA-r^2)M_{32}+D(BH-r_2)M_{23}=2(BA-r^2)$$

Let

$$\theta=BA-r^2$$

Then

$$M_{32}=M_{23}\,\frac{A-D\theta}{r+q\theta}-\frac{AK-Z\theta}{r+q\theta} \quad . \quad . \quad (6)$$

From (5)

$$M_{23}\left\{A-\frac{r(A-D\theta)}{r+q\theta}\right\}=AK-r\left\{\frac{AK-Z\theta}{r+q\theta}\right\}-M_{14}\theta$$

or

$$M_{14}=-M_{23}\left\{\frac{A(r+q\theta)-r(A-D\theta)}{\theta(r+q\theta)}\right\}+\frac{AK(r+q\theta)-r(AK-Z\theta}{\theta(r+q\theta)} \quad . \quad . \quad . \quad (7)$$

(1)

$$A\,M_{41}-M_{23}\left\{\frac{A\,r(r+q\theta)-r^2(A-D\theta)}{\theta(r+q\theta)}+\frac{AKr(r+q\theta)-r^2(AK-Z\theta)}{\theta(r+q\theta)}\right\}+M_{23}\frac{A-D\theta}{r+q\theta}-\frac{AK-2\theta}{r+q\theta}=0$$

or

$$M_{41}=-\frac{AKr(r+q\theta)+r^2(AK-Z\theta)+\theta(AK-Z\theta)}{A\theta(r+q\theta)}+M_{23}\left\{\frac{Ar(r+q\theta)-r^2(A-D\theta)-\theta(A-D\theta)}{A\theta(r+q\theta)}\right\} \quad (8)$$

(3)

$$-\frac{AKrp(r+q\theta)+p(AK-Z\theta)(r^2+\theta)}{A\theta(r+q\theta)}+M_{23}\left\{\frac{Arp(r+q\theta)-p(A-D\theta)(r^2+\theta)}{A\theta(r+q\theta)}\right\}=\frac{ACK-2C\theta}{r+q\theta}+M_{23}\frac{(AC-DC\theta)}{r+q\theta}+qM_{23}=0$$

or

$$M_{23}=-\frac{AKrp(r+q\theta)-(AK-Z\theta)(p\theta+pr^2-AC\theta)}{A(rp+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)} \quad (9)$$

From (6) :

$$M_{32}=\frac{A-D\theta}{r+q\theta}\left\{\frac{AKrp(r+q\theta)-(AK-Z\theta)(p\theta+pr^2-AC\theta)}{A(rp+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)}\right\}-\left\{\frac{AK-Z\theta}{r+q\theta}\right\}$$

$$=\frac{AKrp(A-D\theta)-A(rp+q\theta)(AK-Z\theta)}{A(r+q\theta)(2p+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)}$$

or

$$M_{32}=-\left\{\frac{A(AK-2\theta)(rp+q\theta)-AKrp(A-D\theta}{A(r+q\theta)(rp+q\theta)-(p\theta+pr^2-AC\theta)(A-D\theta)}\right\} \quad (10)$$

From (7) :

$$M_{14}=\frac{-\{A(r+q\theta)-r(A-D\theta)\}\{AKrp(r+q\theta)}{\theta(r+q\theta)\{(A)(rp+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)\}}$$
$$\frac{-(AK-Z\theta)(p\theta+pr^2-AC\theta)\}+\{AK(r+q\theta)-r(AK-Z\theta\}}{\{A(rp+q\theta)(r+q\theta-(A-D\theta)(p\theta+pr^2-AC\theta)\}}$$

$$=\frac{A^2K(r+q\theta)\theta q+AK(A-D\theta)(AC-p)\theta+\theta(AK-Z\theta)(Ap-A^2C-Aqr)}{\theta\{A(rp+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)}$$

or

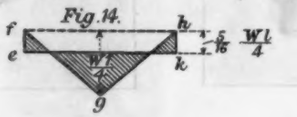
$$M_{14}=\frac{A\theta\{(p-AC)(KD-Z)+q(qKA+rZ)\}}{A(rp+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)} \quad (11)$$

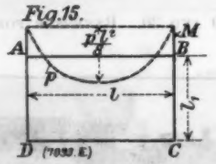
From (1) :

$$M_{41}=\frac{r\theta\left\{(p-AC)(KD-Z)+q(qKA+rZ)\right\}A-A(AK-Z\theta)(rp+q\theta)+AKrp(A-D\theta)}{A\left\{\begin{matrix}A(rp+q\theta)(r+q\theta)-(A-D\theta)\\(p\theta+pr^2-AC\theta)\end{matrix}\right\}}$$

or

$$M_{41}=\frac{\theta\left\{\begin{matrix}AC\,r(Z-KD)+qAK(qr-1)\\+qZ(r^2+\theta)\end{matrix}\right\}}{A(rp+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)} \quad (12)$$





Then if

$$A=(2r+2p) \quad C=(2q+2p) \quad K=-(N+2N_1)$$
$$B=(2r+2) \quad D=(2q+2) \quad Z=-(2N+N_1)$$
$$\theta=3r^2+4rp+4r+4p$$
$$r=\frac{I_0}{I}\times\frac{h}{I_1} \qquad p=\frac{I_0}{I}\times\frac{l}{I_2} \qquad q=\frac{I_0}{I}\times\frac{h}{I_3}$$

$$M_{23}=\frac{AKrp(r+q\theta)-(AK-2\theta)(p\theta+pr^2-AC\theta)}{A(rp+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)} \quad (1)$$

$$M_{32}=-\frac{\{A(AK-Z\theta)(rp+q\theta)-AKrp(A-D\theta)\}}{A(r+q\theta)(rp+q\theta)-(p\theta+pr^2-AC\theta)(A-D\theta)} \quad (2)$$

$$M_{14}=\frac{A\theta\{(p-Ac)(KD-Z)+q(qKA+rZ)\}}{A(p+q\theta)(r+q\theta)-(A-D\theta)(p\theta+pr^2-AC\theta)} \quad (3)$$

$$M_{41}=\frac{\theta\{ACr(Z-KD)+qAK(qr-1)+qZ(r^2+\theta)\}}{A(rp+q\theta)(r+q\theta)-(p\theta+pr^2-AC\theta)(A-D\theta)} \quad (4)$$

When the load W is at the centre of the span and the post 14 is the same as 2 3

$$M_{14}=M_{23}=-\frac{Wl}{8}\,\frac{2r+3p}{r^2+2rp+22+3p}$$

and

$$M_{41}=M_{32}=\frac{Wl}{8}\,\frac{r}{r^2+22p+22+3p}$$

When the load is uniformly distributed and w per foot run,

Special Case, Fig. 14 :

If $r=p=q=1 \quad A=B=C=D=4 \quad \theta=15$

$$K=Z=-\frac{3wl}{8}$$

$$M_{23}=-\frac{3wl}{8}\times\frac{(4\times16)-(11\times224)}{(64\times16)-(56\times224)}=-\frac{5}{8}\cdot\frac{Wl}{8}$$

$$M_{32}=-\frac{3wl}{8}\times\frac{(4\times-56)-(4\times16\times-11)}{4\times16^2)-(56\times224)}=\frac{1}{8}\cdot\frac{Wl}{8}$$

$$M_{14}=-\frac{3wl}{8}\times\frac{60(3\times-15+5)}{64\times16-56\times224}=-\frac{5}{8}\cdot\frac{Wl}{8}$$

$$M_{41}=-\frac{3wl}{8}\cdot\frac{15(16+4-64+1-4+15)}{(4\times16)^2-(56\times224)}=\frac{1}{8}\cdot\frac{Wl}{8}$$

as before for Case I.

$$M_{14}=-\frac{wl^2}{12}\,\frac{2r+3p}{r^2+22p+22+3p}$$

and

$$M_{41}=\frac{wl^2}{12}\,\frac{r}{r^2+2rp+22+3p}$$

Special Case II.—If top and bottom booms and the side struts have the same moment of inertia

Load W Central

Then

$$r=q \text{ and } p=1$$

and

$$A=B=C=D=(2r+2)$$

$$\theta=3r^2+8r+4 \qquad K=Z=\frac{3wl}{8}=3N=3N_1$$

$$M_{23}=\frac{K\{Ar^2(1+\theta)-(A-\theta)\{r^2+\theta(1-A^2)\}}{A\{r^2(1+\theta)^2-(1-\theta)\{r^2+\theta(1-A^2)\}}=\frac{wl}{8}\cdot\frac{2r+3}{(r+1)(r+3)}$$

$$M_{32}=-\frac{wl}{8}\cdot\frac{r}{(r+1)(r+3)}$$

these corresponding with the previous results.

RECTANGULAR FRAME, FIG. 15, WITH INTERNAL PRESSURE, AS, FOR EXAMPLE, A RECTANGULAR TANK SUBJECT TO HYDROSTATIC PRESSURE OR A RECTANGULAR CORN BIN.

At any depth h below the surface of the water the hydrostatic pressure normal to the sides would be $p=wh$ per square foot. The pressure due to corn could be found from Janssen's or other ordinary formula. One foot depth or other convenient portion of the height may be considered.

Let p be the pressure per unit length along each side on a vertical depth of unit length. The work done in bending the side A B is :

$$\int_0^{\frac{l}{2}}\left(M_A-\frac{p\,l\,x}{2}+\frac{p\,x^2}{2}\right)^2\frac{dx}{2EI}$$

where I is the moment of inertia of unit length of the vertical section of the side of the tank about the neutral axis.

The work done in bending the side A D is

$$\int_0^{\frac{l_1}{2}}\left(M_A-\frac{p\,l_1\,x}{2}+\frac{p\,x^2}{2}\right)^2\frac{dx}{2EI_1}$$

where I_1 is the moment of inertia of unit length of the vertical section.

Then the total work by flexure :

$$U=4\int_0^{\frac{l}{2}}\left(M_A-\frac{p\,l\,x}{2}+\frac{p\,x^2}{2}\right)\frac{dx}{2EI}+4\int_0^{\frac{l_1}{2}}\left(M_A-\frac{p\,l_1\,x}{2}+\frac{p\,x^2}{2}\right)\frac{dx}{2EI}$$

Then

$$\frac{dU}{dM_A}=\frac{4}{I}\left(M_A\frac{l}{2}-\frac{pl^2}{24}\right)+\frac{4}{I_1}\left(M_A\frac{l_1}{2}-\frac{pl_1^2}{24}\right)=0$$

or

$$M_A\left(\frac{l}{I}\times\frac{l_1}{I_0}\right)=\frac{p}{12}\left(\frac{l^3}{I}+\frac{l_1^3}{I_1}\right)$$

Let

$$\frac{I}{I}\times\frac{l_1}{I_1}=r$$

Then

$$M_A\left(\frac{1+r}{r}\right)=\frac{p}{12}\left(\frac{l^2}{r}+l_1^2\right)$$

or

$$M_A=\frac{p}{12}\,\frac{l^2+l_1^2r}{r+1}$$

The bending moment diagram for the side A B is sketched in Fig. 15.

When

$$l=l_1 \text{ and } I=I_1$$

$$M_A=\frac{pl^2}{12}$$

This result could have been anticipated, as when the tank is square by symmetry the ends of the sides act as a beam fixed at the ends.

The methods discussed in these articles are applicable to a large number of other problems, and it is proposed to give the solutions for other cases at some future date. In conclusion, the author begs to acknowledge his indebtedness to Mr. J. Collins, M.Sc., who, as a research student, has kindly assisted in the very considerable amount of work involved in these analyses.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 452.)

Longitudinal Strength of Cargo Ships.

The first paper taken at the meeting on Friday morning dealt with the "Longitudinal Strength of Cargo Vessels and its Variation with Fullness of Form." The author was Mr. E. L. Champness, M.B.E., M.Sc., and we reprint it on page 502.

The discussion was opened by Sir John Biles, who said that at odd times many different people had dealt with the strength of ships' hulls, but not in the systematic way that the author had done. He was pleased to note the growing appreciation of investigations of this kind. Different fields, interesting to the naval architect, were being one by one explored. At one time they knew little with certainty as to the resistance of ships' hulls, and when tanks first came into use only special forms were tested. Those fortunate enough to have got a few curves of resistance had to estimate the resistance of intermediate types by interpolation, and when they made changes from established practice, had the hope rather than the certainty that the variations would be advantageous, as there was neither the time nor the opportunity to test the proposals experimentally. He himself had been very glad in past years to receive as a favour from Sir Archibald Denny a few curves of resistance. Now, however, this field had been well explored, and a close estimate could be made of the resistance of any ship form in common use. In the same way, we should gradually learn how the strength of ships varied with their form. In the present case the author had studied the effect of fullness on the strength of ships of the same kind, and last year Mr. Robb had given them a paper on how the strength was affected by the position of the wave along the ship, and on the variation in ship stresses produced by pitching. We had long assumed that the strength of a ship depended on the moment of inertia of its cross section, and on this basis the Load Line Committee had standardised a method of calculating the stresses on the plating. Since the experiments by the Admiralty on the Wolf, we had more assurance than formerly as to the adequacy of this assumption, since it was proved to be reliable for ships of that size. The standard calculations enabled the scantlings of new boats to be fixed by comparison with ships known to have proved satisfactory in service.

The Wolf was a destroyer, and she was, after loading up ready for sea, transferred to a dry dock, where she was supported by blocking so as to produce on the structure equal bending moments to those she would experience on the crest or in the trough of the standard wave. The strains were measured with the Stromeyer strain indicator. The loading was varied by lowering the water level in the dock by 6 in. at a time, and in this way a series of bending moment strains were measured and the stresses deduced. The Wolf was tested both for sagging and hogging moments, so that the observations made covered a great deal of ground. She was then sent to sea, her commander being instructed to chase bad weather. The strains at sea were measured by the same indicators as were used in the dock observations, but were found to be less severe in the ratio of 5 to 8. On this trip the boat was driven at 17 knots through seas so bad that if she had broken her back the only boats she carried could not have lived. The weather encountered was thus very bad, but nevertheless the measured strains were nothing like so severe as if the hull were subjected to the standardised wave loading. These experiments constituted the basis of their faith in the adequacy of the standardised method of computing ship stresses. He noted in Table V that the coefficient C in the formula $C = \frac{W L}{M}$ for hogging stress was remarkably constant for block coefficients ranging from 0·63 up to 0·80, and that this coefficient was almost exactly 35, which Mr. Johns in the 'eighties had given as the coefficient to be adopted when complete standardised calculations were not made. In the case of the sagging moments, the range of values of C was found by Mr. Champness to be from 27·4 to 29·4. It appeared further that the maximum sagging stress did not occur at exactly the same section as the maximum hogging stress. At the best, however, the standardised method of calculation must be qualified by judgment. Observations at sea showed that with full ships the speed at which they could be driven through head seas was limited less by the bending moment stresses than by the amount of "pounding" to which the bottom could be safely subjected. Hence in bad conditions such ships could not utilise their full power when facing head seas. Fine ships suffered less from pounding.

Mr. Thomson, who spoke next, said it was comforting to find the old formula $C = \frac{W L}{35}$ confirmed, and if we omitted in Table VI the boat with a block coefficient of 0·63, which was hardly a practical form, it would seem that we might safely take a coefficient of 30 for the sagging stresses. The bending moment in the latter case might, however, be increased by 10 per cent. or 15 per cent. when two deep tanks were fitted as was common with ships of full form. The curves given by the author in Fig. 4 seem to indicate a somewhat wide gap between Lloyd's rules and the recommendations of the Load Line Committee, but he thought the comparison was not fair as the stress in the bridge deck plating would be less than on the upper deck, and if the stress on the latter were taken as the basis of comparison, the discrepancy would disappear. In practice scantlings must be based on average conditions with a reasonable margin for injudicious loading. This was most to be feared in tankers, where injudicious loading might enhance the bending moments by 30 per cent. or more. Indeed, he had known cases where the increase was 70 per cent. In view of this he thought there was little reason for varying the scantlings with the displacement, but that an average figure might be used. The additional weight of steel required if this policy were adopted might amount to 30 tons in a 400-ft. ship.

Sir Archibald Denny, who followed, said that he had read in 1892 a paper in reply to one read by Sir E. J. Reed in 1890, where arguments had been advanced against the speaker's view that the scantlings for ships of fine form might be smaller than were required for full ships. In Reed's paper emphasis was laid on the increase of stresses occasioned by heaving. In reply, the speaker had admitted that this might be true, but that on the system of calculation then in vogue the sagging stress being small as compared with the hogging stresses, this increase did not matter. On the standard system, hogging stresses were calculated with bunkers empty, and sagging stresses with them full, but Mr. Champness had found that a still less favourable condition might arise with the vessel light, giving a 3 per cent. increase of stress. Nevertheless, the author had come to the conclusion that the finer vessels might have lighter scantlings. With respect to what Mr. Thomson had said, no doubt if they were prepared to accept additional weights they might take the stresses at the upper deck as the standard for comparison; but 30 tons in the case of a fine vessel meant a good deal. As bridge decks got longer they had had to strengthen them, and to avoid this necessity he had, in the case of the Alfonso XIII, built in the 'eighties, introduced an expansion joint in this deck, as he could not, on the limit of weights fixed, afford to plate the bridge deck as he otherwise would have done. He agreed with Sir John Biles that pounding was worse with a full ship. With a fine ship they were, however, liable to get "panting" of the sides if the boat were driven at full power through head seas. He had had a tough struggle to prevent the load line committee definitely laying down the rule that fine vessels required the same scantlings as full ones. The Stromeyer strain indicator used in the experiments on the Wolf was difficult to read in a sea-way, and he thought that use might well be made of the Fereday-Palmer autographic strain recorder.

Mr. Alexander, who spoke next, said that the author had taken as his fixed basis the linear dimension of the ships, and varied the displacement. The proportions were, however, a more important factor than the form. The bending moments to which a ship was subjected were made up of two different sets, viz., those which arose in still water, and those superimposed on these by the waves. No matter how the vessel was loaded, the moments due to the waves, which was the part that varied, were the same, and the range between hogging and sagging stress was the same, whatever the draught. Hence he thought that displacement afforded a better fixed basis to work from than the length. As regards the factor C in the formula $C = \frac{W L}{M}$ he had known cases where it turned out to be far less than the conventional value of 35. In one instance it was as little as 25. The stresses in this ship were over 9 tons forward of the bridge, and considerable strengthening had to be undertaken. In sister ships subsequently constructed this had been met by making the bridge deck higher. In another case a vessel with a tank of 900 tons capacity near the engine room suffered so much damage in a voyage made in ballast that an inquiry was made, from which it appeared that when sagging, the bottom, amidships, was only 2 ft. 6 in. below water, and the stress at the upper deck was 11 tons per square inch. In this case the value of C was about 18. The chief value of the standardised calculations was to enable the insurance societies to investigate such cases as the foregoing, rather than to determine scantlings beforehand. The calculations served to show whether any weakness observed was structural or local. Overstrains due to heaving and pitching were mainly local.

Mr. Whiting read a letter from his son, in which the writer expressed the view that the important factor in ships' strength was the range of the stress above and below the normal, and suggested that valuable information might be obtained by measuring the stresses in tank steamers in dock, varying the load by filling and emptying the tanks. Such experiments would be inexpensive, and the conditions well under control. The observations thus made could then be compared with measurements made at sea.

In reply, Mr. Champness asked leave to deal in writing with the technical points raised. Several speakers had asked for an extension of the inquiry, but it was necessary to limit it to one aspect of the matter, as if every interesting side-line were followed out the paper would never have been completed.

Two-Dimensional Stress.

The next paper, by Professor C. E. Inglis, M.A., was of a purely mathematical character. It was entitled, "Some Special Causes of Two-Dimensional Stress." In it the author showed that by transforming to polar co-ordinates the known differential equations to the stresses in a flat sheet, general solutions were obtained, which, by a suitable selection of the constants, gave the stresses in tapered bars subjected to an axial pull or to bending, and also the stresses in a segment of a flat ring subjected to bending in its own plane. He added that since writing the paper he had learnt that the solution of this latter problem was not new, having been worked out as far back as 1905.

The discussion was opened by Mr. H. M. Martin, who expressed his appreciation of the generality of the results obtained so directly by the transformation of the equations of equilibrium from rectangular to polar co-ordinates. The speaker had himself independently worked out the equations for the stresses in a flat ring, and published them in ENGINEERING, September 5, 1913, and had at the same time developed an approximate solution applicable to machine frames of box or I section, and to crane hooks. The assumption made in making this approximate solution was that the potential energy associated with the radial strains would vary but little for any reasonably possible distribution of the tangential stresses. On this assumption the tangential stress curve turned out to be a hyperbola instead of a straight line, as it was in the case of a straight beam. A comparison of the stresses thus deduced, with those calculated from the exact equations, showed that the error was extraordinarily small. The speaker's attention had been directed to the subject by noticing that the formula for the stresses on a crane hook, with which

Professor Karl Pearson's name was associated, was inconsistent with the premises from which it was derived, and he therefore investigated the matter *ab initio*, arriving, as stated, at the equations given by the author. The latter had, however, covered a much wider field.

Mr. Baker drew attention to the fact that one of the forms studied by the author corresponded somewhat closely to a crank shaft, and that the stresses turned out to be 3·1 to 1½ times more than if, as was usually assumed, the stresses at the bends varied uniformly across the section.

THE ECONOMIC EFFICIENCY OF MERCHANT SHIPS.

AT the afternoon meeting on the 7th inst, at which Sir John Biles was in the chair, the first paper taken was one entitled "The Economic Efficiency of Merchant Ships." It was read by its author, Mr. John Tutin. The object of the paper was to discuss a measure of the economic efficiency of ships, and by analytic methods to indicate how the effect of the many component factors which enter into the final efficiency of a merchant ship can be assessed, and the results applied to design and management. The author pointed out that the question of the economic efficiency of a ship as indicated by profit per pound of capital per annum had only been approached from the technical standpoint within the last two or three years. He took for consideration the fundamental expression for efficiency:—

$$E = \frac{\text{Freight earnings per annum} - \text{charges per annum}}{\text{Capital invested}} \times 100$$

This he developed so as to include the various factors on which earnings, charges and capital costs are dependent, finally arriving at an expression for relative importance by which the values of each factor could be assessed. By this means it was shown to be possible to arrive at the effect each factor had on the final efficiency, the effect any suggested change might have, the effect of different conditions of capital cost, voyage conditions, routes and so on. A numerical example was worked out in an appendix to the paper.

Dr. Percy Hillhouse opened the discussion. He said the subject of the paper was one of considerable importance to which much attention has been paid of late. It could be tackled either by a tabular method or a mathematical one such as the author employed. On the tabular method one prepared a number of sheets with many columns, and in the first entered particulars of a ship on various assumptions. The next were then filled with the same particulars, except that one factor was varied, and so on. The probable profit of each ship specified was worked out, and the effect of variations of one factor or another was clearly shown. The process was cumbersome, but was flexible, and had the advantage that the results and the method of obtaining the results could be easily understood by the ordinary shipowner. The mathematical method was much more rigid, but had the advantage that if the assumptions underlying the values given to the various expressions in the formulæ were correct, then the result which would be obtained by changing any particular item could be very quickly obtained. The paper was a very useful one, and the formulæ it established were not difficult to use. It, however, had the inherent defects of its method. For example it was assumed that the coal consumption and the horse power varied directly. Some such assumption was necessary, but it might not always agree with practice. He could quote an example of two similar Clyde paddle steamers on similar duty, one of which was regularly found to burn 5 tons of coal a month more than the other. This matter was brought to the attention of the engineer of the boat with the larger consumption, and the result was that in the following month he burnt 5 tons less than his fellow. The matter, which was simply one of careful management, illustrated the difficulties which the application of a rigid mathematical method presented.

Mr. E. V. Telfer said the paper was concerned with an interesting subject which gave scope for lots of mathematics. It might be thought that the author had employed plenty, but he would none the less suggest that the treatment would have been improved, if instead of assuming horse-power was proportional to the third-power of the speed it had been taken as proportional to the *n*th power. This would have extended the generality of the treatment. A consideration came into the general case which was not dealt with in the paper. This was the effect which metallurgical considerations might have on the possible developments of size in ships. It would probably be found that the materials of construction would impose a limit. There may have been other determining causes, but it was interesting to note that the American Shipping Board at one time proposed to build 1,000-ft. liners. The idea had, however, now been abandoned. Finally, it might be pointed out that the information given in the paper could be embodied in nomographic charts which could be more easily used than formulæ.

Sir Archibald Denny said that he did not wish to discourage Mr. Tutin, but he thought the paper was very mathematical. It reminded him of his own student days when he was full of mathematics. Immediately his student days were over he had had to take over a managerial job very suddenly owing to the illness of his brother. His firm was at that time building two boats for the Brazilian trade, and he conceived the idea of determining the most economical speed for the boats in view of their size and the trade in which they would be engaged. He went to a lot of trouble in collecting information, and used a lot of mathematics and decided the speed at 11¾ knots. He then brought the matter to the attention of the Board of the shipping company, who listened to him very patiently, and then explained that unfortunately the mail contract in which the boats were concerned called for a speed of 13 knots. This illustrated how frequently pure mathematical considerations were over-ruled by external circumstances. Another factor which had to be remembered was that in any trade there were so many conservative customs that the practical effect of any such investigation as that made in the paper was bound to be very limited. He could not imagine anybody but a Frenchman designing a boat to a formula.

Mr. Alexander said that in the absence of Professor Welch he wished to say how pleased they were with this paper by a student of the Armstrong College, and of the Institution. Practical methods and practical experience were, of course, of the first importance, but it was very valuable to have mathematical treatments of subjects as well as practical ones. There were two kinds of practice; the workshop practice of every day and the practice which could turn mathematical investigations into working rules, curves and diagrams. This was important work to which increasingly close attention was being given, but although it was practical it had to have mathematical treatment at the back of it.

Mr. Tutin, in reply to the discussion, said that the tabular method of treating the problem which had been referred to by Dr. Hillhouse was certainly more flexible than the pure mathematical one, but it hardly served the same purpose. Mr. Telfer's suggestion about the relation of horse-power and speed would certainly make the case more general, but none the less the relation which he had assumed in the paper applied fairly to the great majority of merchant ships, and it was with merchant ships that he was concerned. In reply to Sir Archibald Denny, he would say that in general one could not lay it down that 11¾ knots or any other speed was the most economical. Length of voyage, fuel prices and other variable quantities affected the matter. If mechanical engineering could evolve propelling machinery which could run efficiently over a wide range of speed, a great step forward would have been made towards running ships at their most economical speed as conditions varied.

MOTOR LIFEBOATS.

The final paper taken was one entitled "Recent Developments in Motor Lifeboats." It was read by the author, Mr. J. Rennie Barnett. We reproduce the paper on page 506 of this issue, and may at once proceed to the discussion.

Mr. E. W. Blocksidge was the first speaker. He said that in recent years the proportion of the lives saved from British vessels in distress by the boats of the Royal National Lifeboat Institution had decreased. This was owing to the development of wireless telegraphy and the improvement of life-saving appliances carried by ships themselves. He did not wish to detract in any way from the work of the Lifeboat Institution, but he would point out that what was wanted at the present time was more powerful lifeboats fitted with wireless telegraphy. He thought there was really no justification for the self-righting type of boat now when boats were not required to pass through surf. Better stability was obtained in the non-self-righting type. He approved of the wood construction. It certainly gave the best results, and recent experience on the Clyde showed that it stood grounding better than metal construction. In connection with the New Brighton, 60 ft. boat, he would ask how many people she could carry. There seemed to be little accommodation except in the two cabins. Her range of 150 miles also appeared very small.

Commander Douglas, the Deputy Chief Inspector of Lifeboats, said that he would like to reply to one or two of the questions raised by Mr. Blocksidge. The equipping of lifeboats with wireless telegraphy had received careful consideration, but the Institution was hampered by shortage of funds. With a wireless installation one would require an operator, who would have to be a permanent employee and a full-time man. The Institution simply could not afford such an arrangement at the present time, but they had not given up the project, and hoped that in time cruising boats fitted with wireless would be built. The question of self-righting and the statement that boats were nowadays not required to pass through surf he could not agree with. It was only a few months ago that a boat was capsized and righted herself. None of the crew was lost, and she saved four lives. Something of the same kind occurred with the Brixham boat about a year ago.

Mr. Evans said that in the design of lifeboats there had been a continual struggle between engineers and naval architects. Trouble owing to water-getting to the engine had been long-standing, and the Institution had finally had to set to work on the problem themselves, and had tried for ten years to produce fittings which would really protect the engines against water. As in other matters they had been hampered by shortage of funds. The latest arrangements were satisfactory, but they were due to a general advance in engines and details and not to any important departure.

Captain A. H. F. Young wished to offer his congratulations to the Royal National Lifeboat Institution on building a 60-ft. boat. He was not altogether in favour of self-righting boats, and thought prevention was better than cure. He would be inclined to rely more on the form of the boat, and would fit a buoyant rubbing strip which as the boat rolled would dip. This would minimise rolling. He would like the Lifeboat Institution to consider this, but believed they were wedded to self-righting boats. As far as materials of construction were concerned there was no question but that wood was the best. The Institution had been well advised to adhere to it. The Lifeboat Institution was carrying on one of the most humane works in the country, and he trusted they would continue under voluntary effort and would keep clear of the interference which must follow State assistance.

Mr. W. J. Luke, referring to the development of life-saving appliances on ships, which had been mentioned by Mr. Blocksidge, said that in spite of progress of this kind the lifeboat service was still necessary. Its technicalities could not be in better hands than those of the author of the paper.

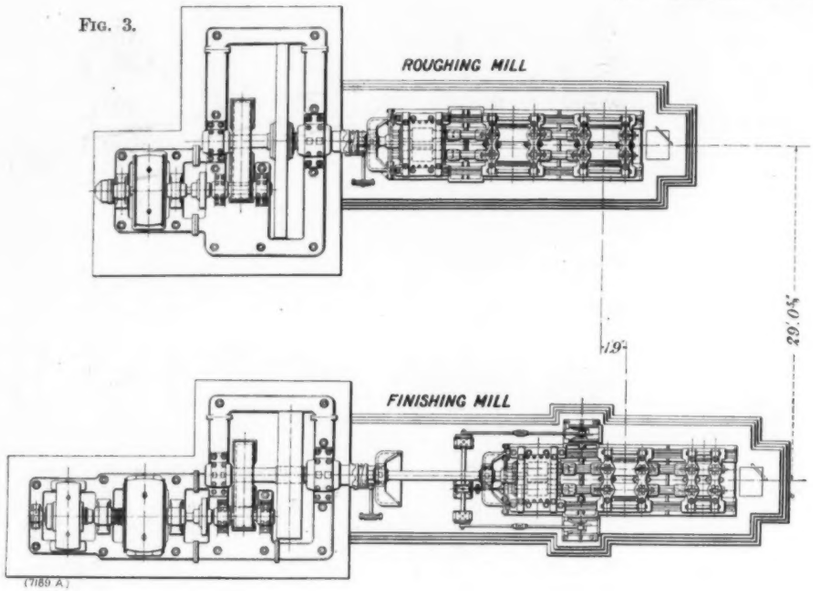
Mr. Barnett, replying to the discussion, said that the 60-ft. boat described was the first what might be called sea-going boat which had been built by the Institution. It was the first example in which a wireless telegraphy installation might be desirable. The matter had not been lost sight of. In reply to Mr. Blocksidge's question about accommodation he would say she could carry from 100 to 150 people. On the self-righting question he would say that he would never design a boat that way if he could avoid it. On certain parts of the coast, however, the crews insisted on self-righting boats. The New Brighton boat had a rubbing strip consisting of an 18-in. coil of rope. The buoyant strip

DOUBLE TWO-HIGH ROLLING MILL FOR THE IMPROVED STEEL COMPANY, LIMITED, TIPTON.

CONSTRUCTED AT THE FRASER AND CHALMERS ENGINEERING WORKS, ERITH, KENT.

(*For Description, see Page* 485.)

FIG. 3.



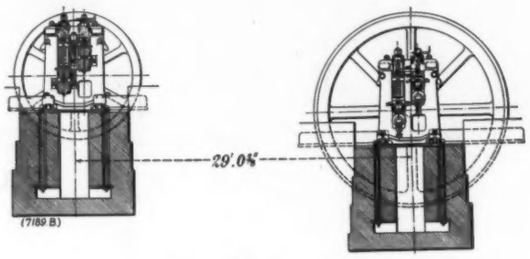


FIG. 4.

FIG. 5.

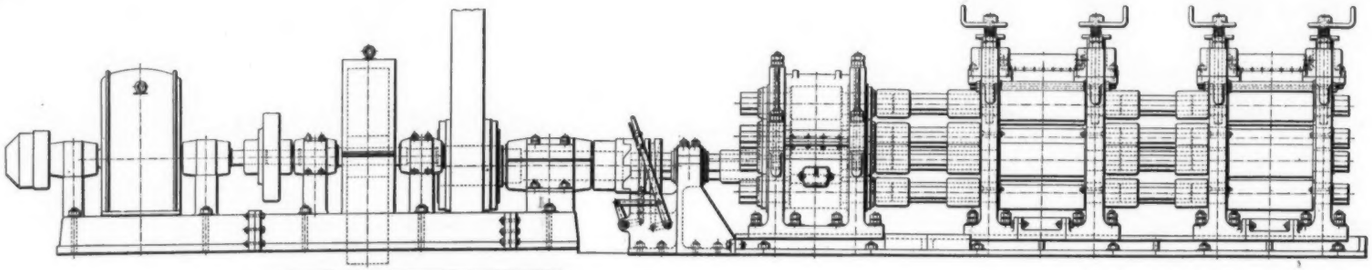
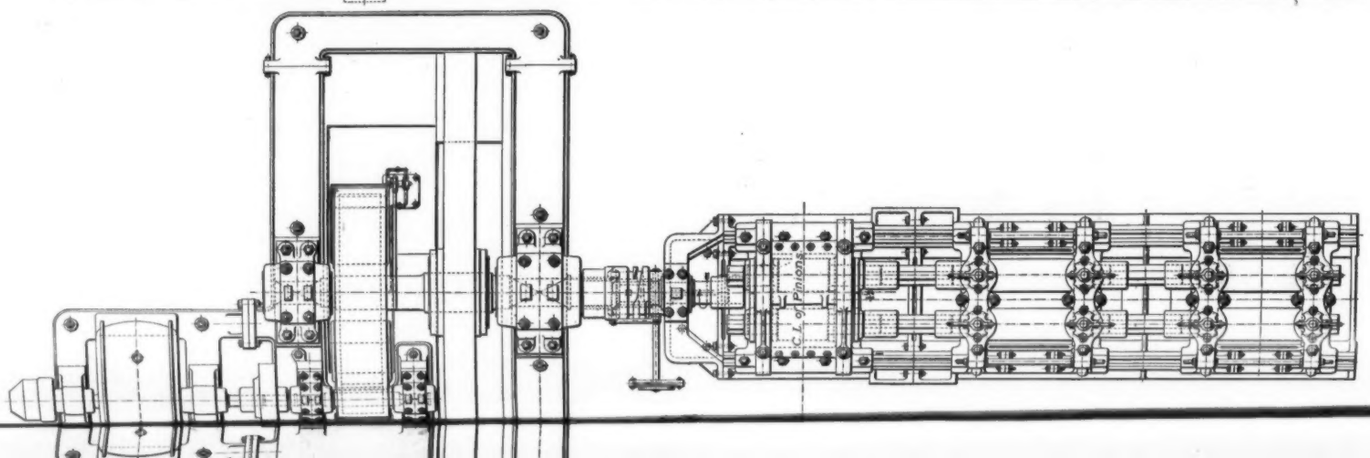


FIG. 6.



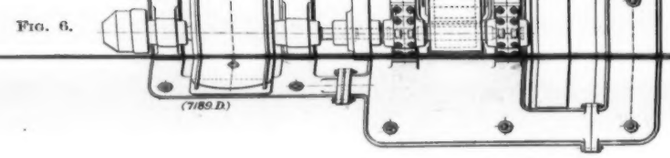
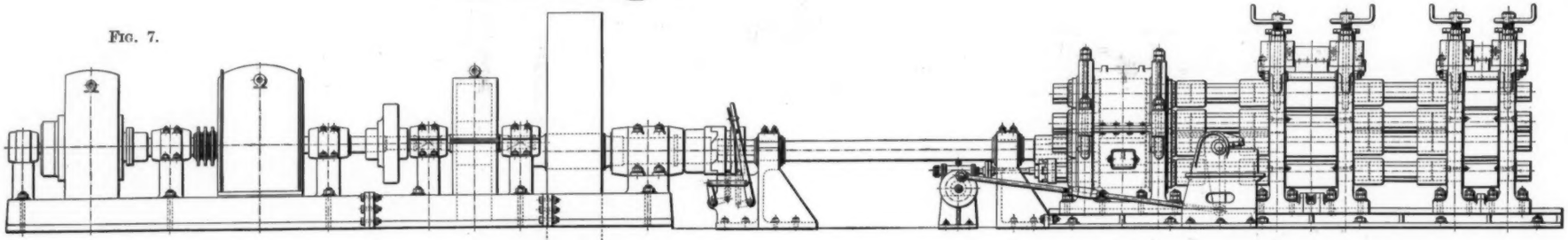


Fig. 6.

Fig. 7.



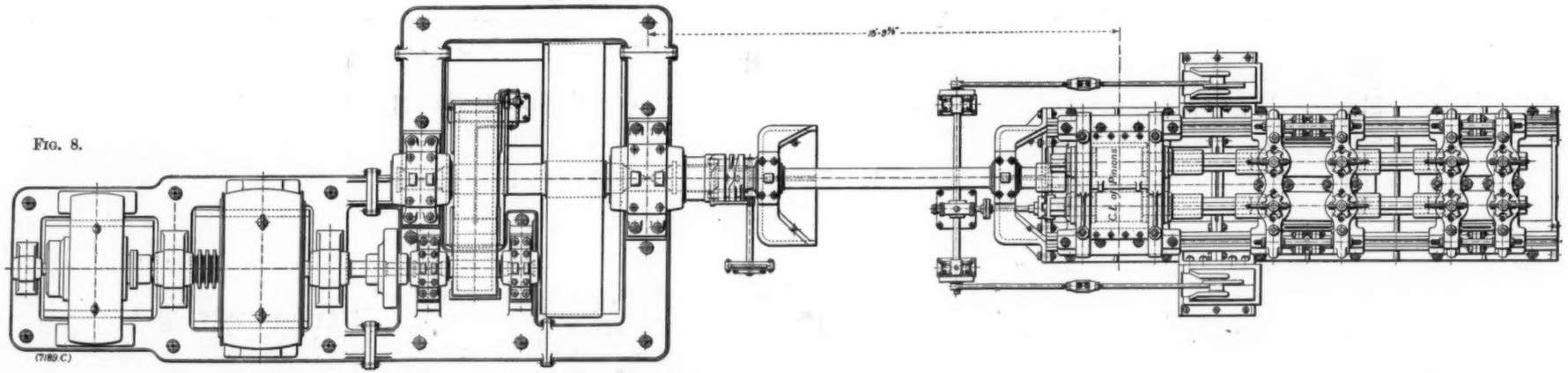


Fig. 8.

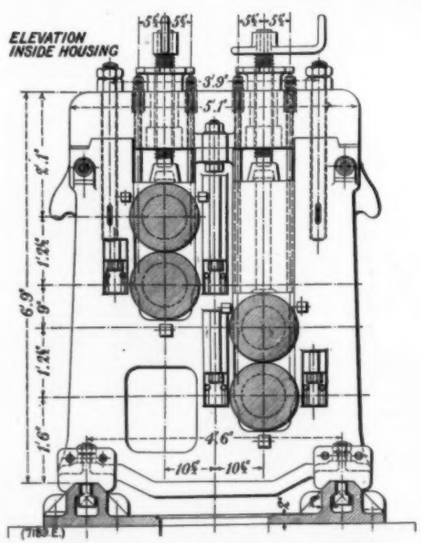


Fig. 9.

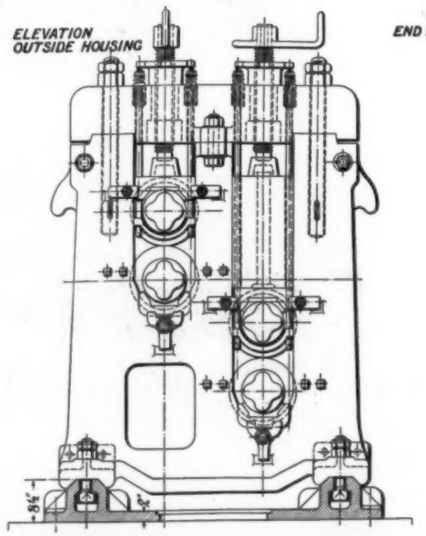


Fig. 10.

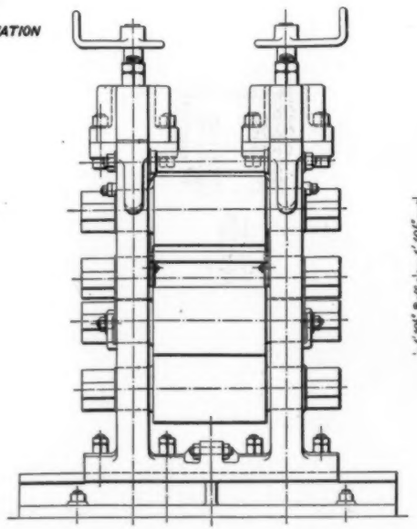


Fig. 11.

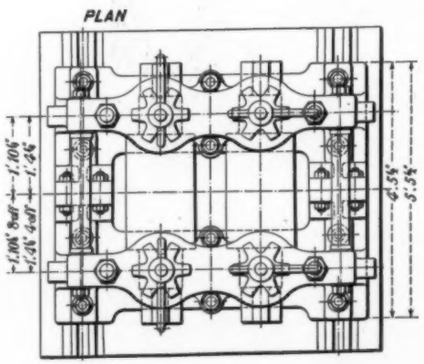


Fig. 12.

AUTOMATIC TRACTOR TIP-CART.

CONSTRUCTED BY THE WEST KENT WORKS, LIMITED, WESTERHAM.

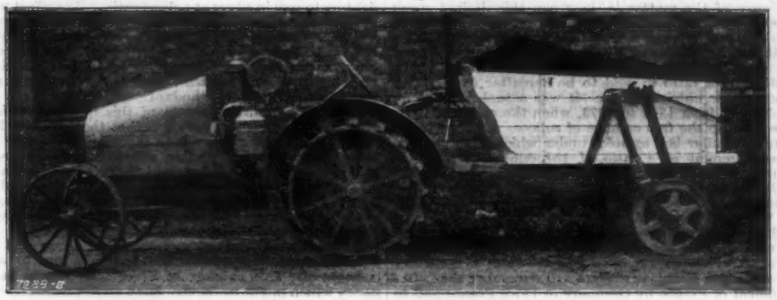
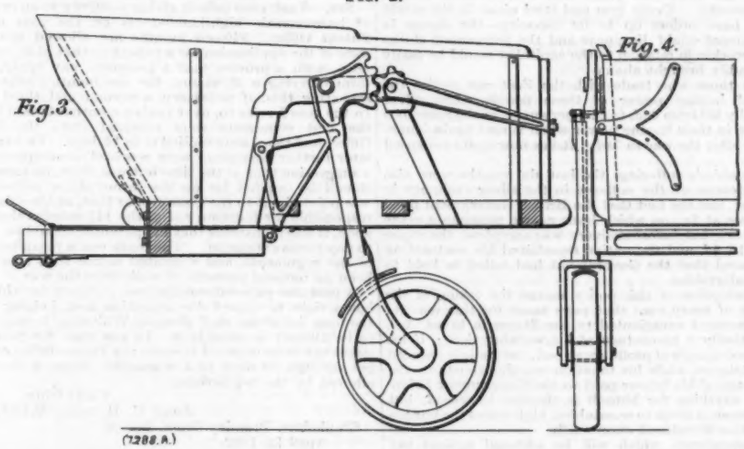


FIG. 1.

FIG. 2.



proposed by Captain Young might have the effect of making the boat too quick. Too much buoyancy had to be avoided. If a boat was too quick in recovering herself when alongside a wreck she was more difficult to handle, and might damage herself.

This concluded the technical proceedings, but before the meeting was closed a vote of thanks to the secretary and his staff for their work in connection with the meetings was proposed by Mr. W. J. Luke and seconded by Dr. Hillhouse. Mr. Dana, in his reply, gave the interesting information that he had been with the Institution for twenty-one years.

AUTOMATIC TIP-CART FOR USE WITH TRACTORS.

THE automatic tip-cart illustrated in the accompanying figures is intended for use behind tractors, and will carry out all the work usually done by the ordinary farm cart. It will go anywhere that a cart will go, but carries a larger load, having a capacity of 2 cub. yards, and in virtue of its method of haulage, of course, travels more quickly. The cart should be of value for any of the purposes for which a farm cart is used, such as collecting roots, carting manure, &c., while it is clearly also applicable for any of the work for which horse-drawn tip-carts are used by contractors. The cart is attached to the trailer by two short shafts, and runs on castor wheels so that it closely follows the track of the tractor hauling it, and is readily manœuvred into awkward positions.

The cart loaded, and in its travelling position, is shown in Fig. 1, while it is shown tipping in Fig. 2. The tipping is carried out by braking the tip-cart wheels and reversing the tractor. The cart castor wheels, as will be seen from the figures, are carried on a bridle pivoted fairly high up on the cart body, and the result of applying the brakes to these wheels and reversing is that, instead of the wheels moving on the road, the body swings over them on the bridle until it reaches the tipping position shown in Fig. 2. If the tractor is then driven forward the whole arrangement will move, maintaining the position shown in Fig. 2, so that the cart is drawn clear of the tipped load. If, then, the brakes are put on the cart wheels and the forward movement is continued, the body will swing back until it is again in the travelling position, as shown in Fig. 1. The whole of the operation of tipping and retrieval of the body can be carried out in about 5 seconds. In general there is no tendency for the cart to tip when travelling backwards when the brakes are off, but it is clear that when manœuvring for position one of the wheels might become blocked against a large stone or other obstruction on the road. This might cause it to tip, and to prevent this a catch is fitted which holds it in its travelling position until tipping is desired. This catch can be operated by the tractor driver without leaving his seat. The same thing applies to the cart brakes, and it will be clear that the combination is a one-man appliance. The tipping and recovery of the cart are done by the driver without leaving his seat.

It will be clear from Figs. 1 and 2 that the tailboard of the cart is automatically raised when it tips. The movement is carried out by the interaction of two toothed segments on each side of the cart, one member in each case being carried by the castor arm and the other by the arm carrying the tailboard. As the body comes back to travelling position the tailboard is, of course, automatically restored to position at the back of the cart. Details of this tailboard arrangement are given in Figs. 3 and 4. The cart may be released from the trailer by taking out a single pin, and, if necessary, several carts may be used with one tractor, so that the tractor has not to wait during the loading operation. If this arrangement is adopted loading stands are required to maintain the carts in position during loading. Such stands are supplied by the makers of the cart, Messrs. The West Kent Works, Limited, of Westerham, Kent.

DOUBLE TWO-HIGH ROLLING MILL.

By the courtesy of Mr. W. Hanby, technical director of the Improved Steel Company, Limited, Tipton, we are able to illustrate on page 492 and in Plate XXI, which accompanies this issue, an interesting rolling mill plant designed and constructed for them at the Fraser and Chalmers Engineering Works, of Erith, Kent; of which works the General Electric Company, Limited, it will be remembered, are now the proprietors. The mills are of the double-two-high type, which is extensively employed on the Continent since it has several important advantages over both single two-high and three-high mills, but is by no means common practice in this country. With the ordinary two-high mill, unless arranged for reversing which involves considerable additional cost, it is necessary to return the bar over the top roll without doing any work on it, so that the tonnage production is comparatively low. The advantages of the double two-high mills, in comparison with the more common three-high mills, are that the rolls used in the former may be shorter—4-ft. rolls in a double two-high mill giving equal production to 6-ft. rolls in a three-high mill—and that finer sections can be produced with less liability to breakdown. Further, the two pairs of rolls in a double two-high mill can be more easily adjusted accurately one to the other than the three separate rolls in a three-high mill can be.

The double two-high mill under consideration has been designed for the production of tyres, ordinary sections, rounds, angles, &c., but is at present engaged in rolling strip from 2 in. to 5 in. in width and of 17 S.W.G. in continuous lengths up to 150 ft. Strips of this length are finished in about 45 seconds from the first roughing pass of the billet, and an output of 50 tons a day of 24 hours can be maintained on this class of work. The plant, photographic views of which are given in Figs. 1 and 2 on page 492, comprises roughing and finishing mills, each having two stands of rolls and the relative position of the two mills is shown by the plan and transverse section reproduced in Figs. 3 and 4, respectively, on Plate XXI. A front elevation and plan of the roughing mill are given in Figs. 5 and 6, while Figs. 7 and 8 are similar illustrations of the finishing mill. Fig. 9 is a transverse section through the rolls of one stand of the finishing mills, showing the inside face of the housing, of which an outside elevation is given in Fig. 10. Figs. 11 and 12 are, respectively, an elevation and plan of one stand of the finishing mill.

As will be gathered from these illustrations, both mills are electrically driven, the roughing mill being operated by a 600 h.p. three-phase induction motor running at 500 r.p.m., and driving the rolls through double-helical reduction gearing at 99 r.p.m. The flywheel mounted on the mill shaft is 17 ft. in diameter and weighs 20 tons. The finishing mill is similarly driven, but the motor, which is also of 600 b.h.p., has a speed range from 400 r.p.m. to 600 r.p.m., which is reduced to 127 r.p.m. to 190 r.p.m. at the mill shaft. The flywheel on the latter is of the same weight as that for the roughing mill, but the diameter is only 11 ft. The electrical equipment was supplied by the English Electric Company, Limited, Kingsway, W.C.2.

The roll housings, clearly shown in Figs. 9 and 10, are of the open-top type, the caps being secured by heavy cottered bolts at each end and by bolts passing

through lugs in the centre. All chocks are of cast steel with gunmetal bushes for the roll necks and are adjusted by dogs secured to the housings by bolts as shown in Fig. 10. The top chock, in each case, is lined with anti-friction metal and is suspended from the cap by bolts and springs. The rest bars, shown in Figs. 1 and 2, are of machined steel and are carried in machined slots in the housings, so that although the position of a bar can be easily changed it is always kept parallel with the axes of the rolls. In comparison with the rough cast-iron rest bars often employed, the above-mentioned arrangement effects a considerable saving of time and labour in setting up guides. The pinion housings, which are cast from a similar mixture to the roll housings, are of heavy construction and are fitted with cast-iron chocks lined with anti-friction metal. The five pinions, which are totally enclosed, are of steel with machine-cut double-helical teeth. Forced lubrication is supplied by a small pump driven by chain from one of the pinion ends.

In general, it may be remarked that every care has been taken in designing and laying out the mill to secure the highest efficiency in operation. In the case of a continuously-running mill it is, of course, necessary to make provision for stopping rapidly for the purpose of adjusting or changing the rolls. This is done by means of a specially designed claw clutch shown in Figs. 5 to 8. From these illustrations it will be seen that two helical grooves are formed on the sliding sleeve of the clutch, and pins, operated by a hand lever, are brought into engagement with one or the other of these grooves to connect or disconnect the clutch. This arrangement enables the mill to be stopped in less than half a revolution, although the motor and flywheel take about 20 minutes to come to rest.

To facilitate the changing of rolls two stands of spare housings are provided and these are fitted up with a set of rolls. To change from one section to another it is therefore only necessary to stop the mill, slacken the bolts securing the housings to the bedplate, lift off one set of rolls and housings complete and replace them by another complete set. The time necessary for this operation is obviously but a small fraction of that required to handle the rolls and housings independently. Two sets of small shears are provided one on each side of the finishing mill, to cut off the bad ends that come through from the roughing mill. They are set at a convenient height from the floor so that the end of the bar can be thrown in before it enters the finishing rolls. The speed of the shears is such that from 20 cuts to 30 cuts can be made per minute.

The mill above described is served by two Smallwood regenerative furnaces constructed by the Incandescent Heat Company, Limited, and fired with producer gas. The two furnaces are capable of heating 100 tons of billets, ranging from 60 lb. to 100 lb. in weight in eight hours. We understand that the plant, which has now been in use for several weeks, has proved entirely satisfactory and that the output has exceeded the specified amount.

REMEDY FOR SHRINKAGE IN WORLD'S OVERSEA TRADE.

TO THE EDITOR OF ENGINEERING.

SIR,—No one to-day needs proof of the shrinkage in the world's oversea trade—what we all require is a remedy for the existing trouble. There are plenty of doctors ready to prescribe treatment for the patients suffering from paralysis of trade, but so far as I can judge a cursory analysis of the proposed prescriptions is sufficient to tempt us to throw them into the waste-paper basket as quack remedies. If I may try and diagnose the world trouble to-day, and its inability to get back to the pre-war volume of commerce, I would make the following notes :—

Thirty thousand million pounds sterling expended in four years absorbed the savings of half a century and committed Governments to the issue of paper money or promises to pay at future dates to all who were ready to advance cash secured by interest-bearing bonds. The issue of this paper money has, in three cases, been followed by an awful debacle, the paper issues being rendered practically valueless—Russia, Austria, Poland. Whether the paper issues of a dozen other countries that might be named can ever be liquidated is one of the problems we are anxious to solve. A Government issue of paper money is good so long as that Government's credit is stable, but the moment the outside world doubts the solvency of a Power, its paper issue immediately begins to depreciate in the markets of countries outside itself—this, therefore, we put in the forefront of our diagnosis —Unsound money.

The next trouble, during and after the war, was that the available capital in the world was so locked up, international credits were so obstructed, as to positively prevent business being carried through on the accustomed lines of selling on bills of exchange accompanied with bills of lading and insurance policies drawn on buyers in foreign countries at six, nine and twelve months' time.

The two root causes of our present trouble are: (1) Breach of faith by Governments issuing paper far beyond their possibility of redemption. (2) Withdrawal from commerce of enormous sums which had previously been the circulating lifeblood of international trade.

The cure for the first is, in my opinion, impossible until the remedy for the second cause has been found. When money for international trade is again available in pre-war abundance, half the trouble will be faced—the crux of the matter is, how can this desired result be effected? It can be done in two ways. One, by twenty to thirty years scraping, saving and hoarding until the amount burnt up by the war is replaced, and the other by making legal tender, in international trade, of silver in a ratio to gold to be hereafter fixed. This is no new or untried theory—it was actual practice for six decades from 1814 to 1873, when the mints of India were open to the free coinage of rupees. In the United States a similar law existed, under which silver bullion to any amount at a ratio of 15½ ounces of silver to 1 ounce of gold was legal tender and in France, the head of the Latin Union, the holders of gold or silver could demand that the same be minted at the same ratio as in the United States of America.

There is no real reason why this policy, which kept the exchanges of the East and West without fluctuation for sixty years, should have ceased—from a monetary point of view, but your readers will remember that after the defeat of France by Germany in 1870, France had to pay a huge war indemnity of two hundred million pounds sterling, which Germany demanded in gold and, in addition, asked for the coinage of Germany's surplus silver by France into more gold coin. This demand was resented by France—her mint was closed to the coinage of silver which for sixty years had remained at about 60*d.* per ounce, and from that time gold and silver were divorced. The point I claim is, that there is no logical or historic reason why in our present trouble we should not revert to the policy of sixty years—1814 to 1873—by a resolution to be passed at the Genoa Conference or some International Convention, under which the mints of the great nations shall be thrown open to coin silver at a fixed ratio to gold and all nations shall receive silver at this ratio in full payment for goods. The immediate result would be that the exchange between Calcutta and Shanghai, London and New York would automatically fix itself and remain stable on that basis. A further immediate result would be that the hoards of silver existing in India and China would increase the buying power of 700,000,000 people to such an extent that the development of these two vast countries would immediately start the world into active trading and the silver received in payment for goods, railway equipment, &c., would be passed on to other countries in exchange for commodities which, in my mind, would so stimulate international trade that every steamer afloat would within the next five years find remunerative freight engagements. Every iron and steel plant in the world would have orders up to its capacity—the slump in employment would disappear and the permanent status of the worker in relation to the capitalist would be easily and readily brought about.

Only those who trade with the East can realise the reduced buying power of these people when silver gradually fell from 60*d.* to 22*d.* per ounce, or the enormous increase in their buying power when it rose again immediately after the war to 78*d.* It has now again collapsed to 33*d.*

Lancashire's sufferings the last six months were also the outcome of the collapse in the silver exchange in the East, and the fact that the British Government fixed the rupee at 2*s.*, on which basis native merchants made contracts; but before delivery was complete, the rupee fell to 1*s.* 4*d.* and the native repudiated his contract on the ground that the Government had failed to hold to their undertaking.

The adoption of this policy means the easing of the position of every man that pays taxes for this reason: Every amount contributed to the States in taxes, &c., is practically a percentage of his working time; if his wages and margin of profit are so bad, the trade is reduced to a minimum while his taxation remains constant, the percentage of his labour paid to the Government before he has anything for himself is thereby increased, but with a boom in trade to re-establish high wages the burden of taxation is reduced enormously.

The arguments which will be adduced against my proposition are—that people who owe money will be able to pay their debts more easily with an option of silver and/or gold, as against gold or its equivalent, the only medium of payment at present. This is perfectly true, but the holders of mortgages and gold bonds may have to face the other issue if no action is taken, and the value of their bonds will seriously shrink in the next ten years. In my opinion, the holder of interest-bearing bonds would be well advised to accept his interest in silver than run the risk of decreased capital value.

Another argument is that this policy would give an unfair impetus to countries where large quantities of silver were unobtainable—my reply is that these countries would immediately become purchasers of foreign manufactured goods—develop their countries with railways, factories and scientific plant: they cannot use the silver without benefiting the dealers in other commodities and giving employment in other countries.

A further argument is that silver can be produced in such volume as to force accumulation which could not be digested in commerce—my reply to this, after careful investigation, is that no such result would be possible inside fifty years as, in addition to vast trade to be opened up in Africa and other countries where silver is chiefly used, and could be used in still larger quantities, there is the world necessity to-day that all countries with debased paper currency must put some sound money behind any new paper issues they make and, in my opinion, the adoption of the joint mercantile use of silver and gold would enable these countries to put aside as reserve a percentage of their imports of silver received in payment for commodities and by the acceptance in silver of payment of taxes, &c., to build up such reserve.

To those who still believe a reversion to the gold standard is the only sound policy for permanent stability I would say that the best way to break up the present gold monopoly is to find a substitute in the option of all debtors to pay in silver at a fixed ratio. The effect would be that many Governments who passed laws preventing the export of gold from their reserves would withdraw the prohibition and gold would naturally flow into the pre-war channels of currency but, while the existing prohibition of gold remains, there is no possible hope of the return of the gold standard.

There is a political aspect of this question which is very little understood, and it is that the unrest in India during the past few years is, in the opinion of many well-informed students of Indian affairs, largely caused by the demonetisation of silver and the fact that the natives who hoarded silver prior to 1893—when the free coinage of the rupee was revoked, has found his hoardings of years—sometimes generations—rendered valueless in times of famine to purchase the necessities of life. The reinstatement of a fixed ratio between silver and gold would immediately enable the Indian mints to again open to the free coinage of silver into rupees at the parity which might be fixed. Such an Act would do more to strengthen British authority in India than any amount of native participation in Government which may be offered. One salient fact in this connection is that a large percentage of the natives are, and always have been, in debt to moneylenders, and the moment his hoards of silver were not available to pay the interest on these debts, the moneylender increased his demand and this practically added a third to half of the amount of his original debt. It needs no argument to show that if 100,000,000 of these people were in this position (I believe the percentage is larger) the agitators had a ready-made weapon put in their hand wherewith to incite the natives against a Government which allowed such an injustice to be perpetrated upon them.

Your readers may readily imagine other reasons why the present proposal is either illogical or unworkable, and I feel sure your columns will be open to business men who like myself are anxious to find a lasting solution of the present impasse and will contribute their criticism to a free discussion of the world's reconstruction of its commercial stability.

Yours, &c.,
ALFRED BIGLAND.

House of Commons, April 13, 1922.

PATENT OFFICE METHODS.

TO THE EDITOR OF ENGINEERING.

SIR,—I ask your help in giving publicity to an example of bureaucratic high-handedness on the part of the Patent Office. Fifteen months are allowed from the date of the application for a patent to that of its acceptance, with a proviso that a patentee may apply, on a form carrying a 2*l.* stamp, for one month's extension, repeating this, if necessary, a second and third time. In the case I refer to, over twelve months elapsed before the first comments were received from the Patent Office, and these were replied to in 14 days. Two months later further comments were received, accompanied by a suggestion that as the time left was short, an extension should be applied for on the terms above named. It was pointed out to the Comptroller that, as his office was responsible for fourteen out of the 14½ months that had gone, it was monstrous that the patentee should be asked to pay for an extension. The reply was a recapitulation of the regulation, and a printed notice that there had been an unusual pressure of work since the war.

A patentee pays substantial fees, in return for which he has a right to expect due attention and, judging from the long list of the staff given in Whitaker, it ought not to be difficult to provide it. In any case, the patentee ought not to be mulcted because the Patent Office cannot get through its work in a reasonable share of the time allowed by the regulations.

Yours truly,
JOHN G. HUDSON, M.Inst.C.E.

Glenholme, Bromley Cross, Bolton,
April 15, 1922.

"THE INTERCHANGE OF IDEAS."

TO THE EDITOR OF ENGINEERING.

SIR,—Your editorial on "Interchange of Ideas" is both interesting and valuable, the more so if it is extended to the translation of practice from one group in engineering to another, as well as within a group. In particular your article on the new Great Northern locomotive and American practice founded on the data obtained by the Pennsylvania Company from their testing plant, is most apt. Higher commendation is due to Mr. Gresley for making use, if he has done, of all available knowledge modified to conform to his own practical experience, than for ignoring it. Apart from American practice there is ample knowledge of the value of alloy steels as established in aero engine practice, in this country. One of the greatest difficulties in engineering is to induce those engaged in one branch to make use of the data made in another. A comparison of the new engine with the "Claughton" class of the North-Western with their respective boiler and cylinder capacities presents difficulties to the outsider; possibly the double heading still employed even with the latter type at a time when economy of operation is so paramount may be some explanation.

The Great-Western testing plant—the only one in the kingdom—if thrown open to all railways for comparative tests of all types, say under the ægis of the Institution of Mechanical Engineers, would be of national advantage.

The condensing locomotive is again with us, the great gain in fuel economy cannot be gainsaid; yet it seems strange it is not tried out in its simplest form—direct drive. In land practice the latest engines of a power similar to that of a locomotive are uniflow central exhaust ones—there is such a locomotive on the North-Eastern; why not fit it with a condensing tender and exhaustively test it?

Though the internal-combustion engine has become the standard prime mover for transportation on roads, and is becoming more and more so for the sea, yet it has hardly yet made its appearance on railways where its chances of economy are greatest. I often think how interesting it would be to hear a paper on one branch of engineering by an expert in another.

Yours faithfully,

ALAN E. L. CHORLTON.

Junior Carlton Club, Pall Mall, S.W. 1.
April 17, 1922.

"THE CHEMICAL ENGINEER."

TO THE EDITOR OF ENGINEERING.

SIR,—In view of the proposed new Institution of Chemical Engineers now being formed, and the statement of Professor H. E. Fierz, of the Technical High School in Zurich, Switzerland, that they do not know the "so-called chemical engineer," it would seem that some consideration is still required to decide what constitutes a chemical engineer; and what scope exists for his work.

Professor Fierz is the author of a book which has been translated into English as "The Fundamental Processes of Dye Chemistry," 1921, and his remark, which is published in the Journal of the Society of Chemical Industry, March 31, 1922, page 114R, continues with the statement that "all our chemists have a real university education." It is probably justifiable to presume that Professor Fierz does not mean by this that the chemists become sufficiently qualified as engineers to dispense with ordinary civil, mechanical and electrical engineers, but that they have a general knowledge of engineering, and know the type of plant they will require to carry out their proposed processes.

The present writer believes that this is the point to which consideration can well be given in order to acquire clear views as to the engineering work required in chemical factories. It is obvious that every chemical factory requires buildings, roads, drains, water mains, generally gas mains, also probably railway sidings. These are usually considered civil engineers' work. There are then inside the buildings water, gas, compressed air, vacuum, steam mains and shafting. Those with the boiler plant, steam engines (if any), compressors, vacuum pumps, fire pumps, hoists and general conveying and elevating machinery are the mechanical engineer's province. Then practically every chemical works is now provided with electric light and power, so that we have the electrical engineer, even when no electrolytic work is to be carried on. It is only after all the foregoing are provided or at least planned out that the work of a specialist chemical engineer would begin.

Up to this stage the chemists have only had a general interest in the lay-out of the buildings, &c., but from the point onwards, in the writer's opinion, they have to take the lead and the responsibility. It is the duty of the chief chemist to instruct the engineer as to the proposed processes, and give him sufficient information to prepare plans, which should then be discussed in detail between them, and each drawing initialled by both. The chemist should be responsible for the suitability of the plant for the process proposed, and should also be able to decide as to the metals and jointing materials to be used for the various parts. The engineer should be responsible for the capacities of the items, thicknesses of metal, safety in working, and quality of workmanship.

As the plants will generally include some, or all, of the following, the engineer should be acquainted with them all: Stirrer pans, vats, filters, ovens, stills, rectifiers, autoclaves, pumps and fans, and with the various materials from which they can be made, and the various types of each. It is presumably in the knowledge of these items that the chemical engineer will specialise, and in which he will find that the chemist will also have a considerable knowledge gained by experience of process working. Whether the engineer will or will not be able to originate anything of value will to a great extent depend upon the work to be done. In what is called the heavy chemical industry, it is possible that he could do so, but generally speaking in new work on synthetic dyes, he could not, as the processes first adopted are very likely to be changed entirely for new processes for chemical reasons, on account of difficulties due to impurities or excessive costs, and the decisions must in these cases rest entirely with the chemist. Although the chemist may have engineering knowledge, it would be very unwise for him to spend time to qualify himself to discuss questions of strength of materials or design, though he can give very useful help as to lay-out for convenience in working.

It will be fairly obvious that few works in England are large enough to have a chemical engineer, in addition to a mechanical and electrical engineer, and a civil engineer. The great majority will only have one engineer, assisted by a foreman and a draughtsman. It would appear therefore that to meet these circumstances, the chemical engineer should have the following knowledge:—

Civil engineering so far as relates to general building in brick, ferro-concrete, and structural steel, drainage, and water and gas supplies.

Mechanical engineering: Good general knowledge, as he will have steam engines, possibly gas engines, gas producer plants, compressors, vacuum pumps, circulating pumps of all kinds, fans and shafting, and pipe lines, probably measured in miles.

Electrical engineering: General knowledge of arrangements of wiring, motors, switches, &c., and in some cases of power station works, though if the works are sufficiently large for generating their own power, they will generally have a special electrical engineer.

Chemical engineering: Clear and detailed knowledge of the many types of items of process plant mentioned previously, and of the metals, alloys and jointing which may be expected to give satisfaction in dealing with the various chemicals to be treated. Also he had better have or acquire a sense of humour and diplomacy, as the chemist will necessarily have aims and requirements which neither the engineer nor the materials can easily satisfy.

The more experienced the reader, the more probable is it that after studying the above, he will conclude that a good general engineering training and experience, particularly experience, will form the best foundation on which to build up the knowledge of the special chemical engineering items. A university training is no more capable in this, than in any other branch, of turning out a qualified experienced engineer, but it should be capable of turning out men with a training to make them capable of rapidly acquiring a useful knowledge of the various items, and the writer would suggest that it would not be an advantage to devote more time to chemistry, but that they should get a thorough grounding in mathematics, physics, and the usual subjects already taught to mechanical engineers, with as much electrical engineering as can be worked in.

The writer does not know if it will be possible to find a sufficient number of chemical engineers to form an Institution, if the qualifications are kept sufficiently high, but at least 120 have apparently expressed their willingness to join. The Society of Chemical Industry serves a very useful purpose, and its publications are valuable, but unfortunately membership implies no professional qualifications. The object of the proposed new Institution is to raise the standard of chemical engineering generally, as has so well been done for other branches by the senior institutions. The number 120 would, of course, be more than the older engineering institutions began with. Many possible members are already members of the senior institutions. A very noticeable feature with regard to consulting chemical engineering is that many of the new dye manufacturing works are reluctant to allow any but their own engineers to obtain access to their works. This may be ascribed to the fact that they are generally working on licensed German patents, and not on their own patents.

Yours, &c.,

GEO. W. SHEARER, Wh.Sc., B.Sc.,
A.M.Inst.C.E., A.M.I.E.E.

"THE PRODUCTION OF ACCURATE SCREW THREADS."

TO THE EDITOR OF ENGINEERING.

SIR,—In letters appearing in the issue of your journal of March 24, 1922, we read that the size of taps seem to be still a problem at Holm Foundry, Cathcart. In 1917 (during the war) tap sizes gave no end of trouble due to the fact that a new tap was considered accurate when it was not. The writer, with thirty years of American experience, the greater part in actual touch with close work, advised that all taps be graded into accurate, minus and plus values. Minus and acid reduced plus taps to be used for machine taps while the accurate taps were to be used to standardise and finish the holes. It is no special job to reduce a tap; when acid of known strength is used, the time a tap remains in the acid can be used to determine the amount of reduction with very little experience necessary to do it. "The Hartness screw thread comparator" can be relied on to inspect taps and external threads.

I am,

JAMES MCINTOSH.

2964, Corydon-road, Cleveland Heights, O., U.S.A.
April 7, 1922.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A meeting of this Institution is to be held in the Eastern District at Chiswick, on Saturday, the 29th inst. Further data can be obtained from Mr. J. Julian, Borough Engineer and Surveyor's Office, Guildhall, Cambridge.

THE LATE MR. JAMES PORTER MAGINNIS.—We regret to have to announce the death, which occurred on the 14th inst., of Mr. James Porter Maginnis, who was a member of the Institution of Civil Engineers and of the Institution of Mechanical Engineers. Mr. Maginnis was born in March, 1850, and served his apprenticeship from 1867 to 1870 in the shops and drawing office of the Worcester Engine Works Company; he then entered the Stourbridge offices of Mr. E. B. Marten as an improver, where he remained until 1871, when he was transferred to Middlesbrough as resident engineer for the Midland Steam Boiler Inspection Company, of which Mr. Marten was chief engineer. In 1874, he became assistant surveyor to the South Staffordshire Main Drainage Commissioners. In 1877, Mr. Maginnis was appointed chief draughtsman to the Institution of Mechanical Engineers, and in 1883 he established a practice as consulting engineer. In 1884, Mr. Maginnis succeeded the late Mr. W. R. Browne as engineer in this country of the Russian South-Western Railways, a position which he occupied for many years whilst conducting his general engineering consulting work.

SEPARATION OF OIL FROM ROCK AND SAND.

A GOOD deal of the natural oil is brought up to the surface in association with a large proportion of sand. The sand cannot be excluded without interfering with the oil flow below; the oil has to be allowed to settle in reservoirs, and the sand subsequently to be piled up in large dumps which retain a considerable percentage of oil. When the petroleum breaks out in gushers, many acres of ground may become saturated with oil. According to the United States Bureau of Mines, 4,000,000 barrels of oil were lost in the soil, and covered by a sticky, asphaltic crust, when the Lake View gusher overflowed the hastily-constructed reservoir which was to hold 10,000,000 gallons. Similar losses are not rare, and the Bureau estimates that between 10 per cent. and 15 per cent. of all the oil raised in California is wasted in this way. At Pechelbronn, in Alsace, where P. de Chambrier introduced shaft mining of the oil-bearing sands, as we mentioned last year, the boring and draining leave still 40 per cent. of the oil or bitumen adhering to the sand. Extraction and washing have so far remove this only in a very imperfect way. Thus the recovery of oil and bituminous matter from the rock or sand to which it adheres is a matter of technical importance, especially also with regard to the tar sands of the Athabasca River and other districts, under which name the vast oilfields near Forts Murray and McKay have been described in the official report drawn up for the Canadian Department of Mines by S. C. Ells.

The problem of the "Separation of Adhering Oil or Bitumen from Rock" was recently brought before the Society of Chemical Industry (Journal of the Society of January 31), by Dr. Ernest Fyleman, F.I.C. The means generally employed for separation are extraction with organic solvents, distillation and washing with hot or cold water. The first two methods are very expensive; distillation, moreover, does not yield the valuable bitumen as such. Washing with water is inefficient because the interfacial tension σ between mineral matter and oil is generally lower than that between mineral matter and water, so that a large amount of energy is required to overcome the attraction between the mineral grains and the films of organic matter covering them. When we have a rock R covered with oil O, however, and a suitable solution (not merely water) A be added to the system, the interfacial tensions will respectively be σ_{RO}, σ_{RA} and σ_{OA}, and a rearrangement of the phases will take place, when the total energy of the system is reduced by the addition, *i.e.*, when the sum of the surface energies of the new interphase surfaces is less than the surface energy of the old interphase surface which is being eliminated. When, therefore, σ_{RO} is greater than the sum of $\sigma_{RA} + \sigma_{OA}$, the oil will be sheared off from the rock, which will be wetted by the solution. A soap solution should, of course, be suitable for this purpose, and Dr. Fyleman demonstrated that it will clean sand off oil in the cold; when the rock is bituminous, hot solutions are required or a little petroleum oil should be added to the alkaline solution to render the bitumen fluid. Very dilute solutions are sufficient. Since many oils are slightly acid, a little soda ash may do. For the treatment of the tar sands of Alberta, Dr. Fyleman recommends a solution of 0·1 per cent. of sodium carbonate in water of 80 deg. C., gently stirred; the fine sand then separates from the particles of bitumen which ball together and do not pass through the sieve, after the mass has cooled. Solutions of soap or saponin may also be used.

Dr. Fyleman placed a cost estimate for the treatment of Alberta tar sands before the meetings. These sands are said to contain 10 per cent. and more of bitumen; what the average contents is, it would be very difficult to say, for the tar sands are believed to extend over thousands of square miles, and the layers vary greatly in thickness. But Dr. Fyleman may be right in estimating that his separation would not cost far less than a dollar per ton of bitumen and that this item would be small compared to the expenditure on quarrying and transporting the material. The trouble on the Athabasca is the inaccessibility of the district and the limitation of the time for operations by the severity of the climate. But those particular difficulties are absent in other cases, and the treatment of the oil-sand dumps might be taken up seriously, though contamination of the oil with any chemicals is not desirable.

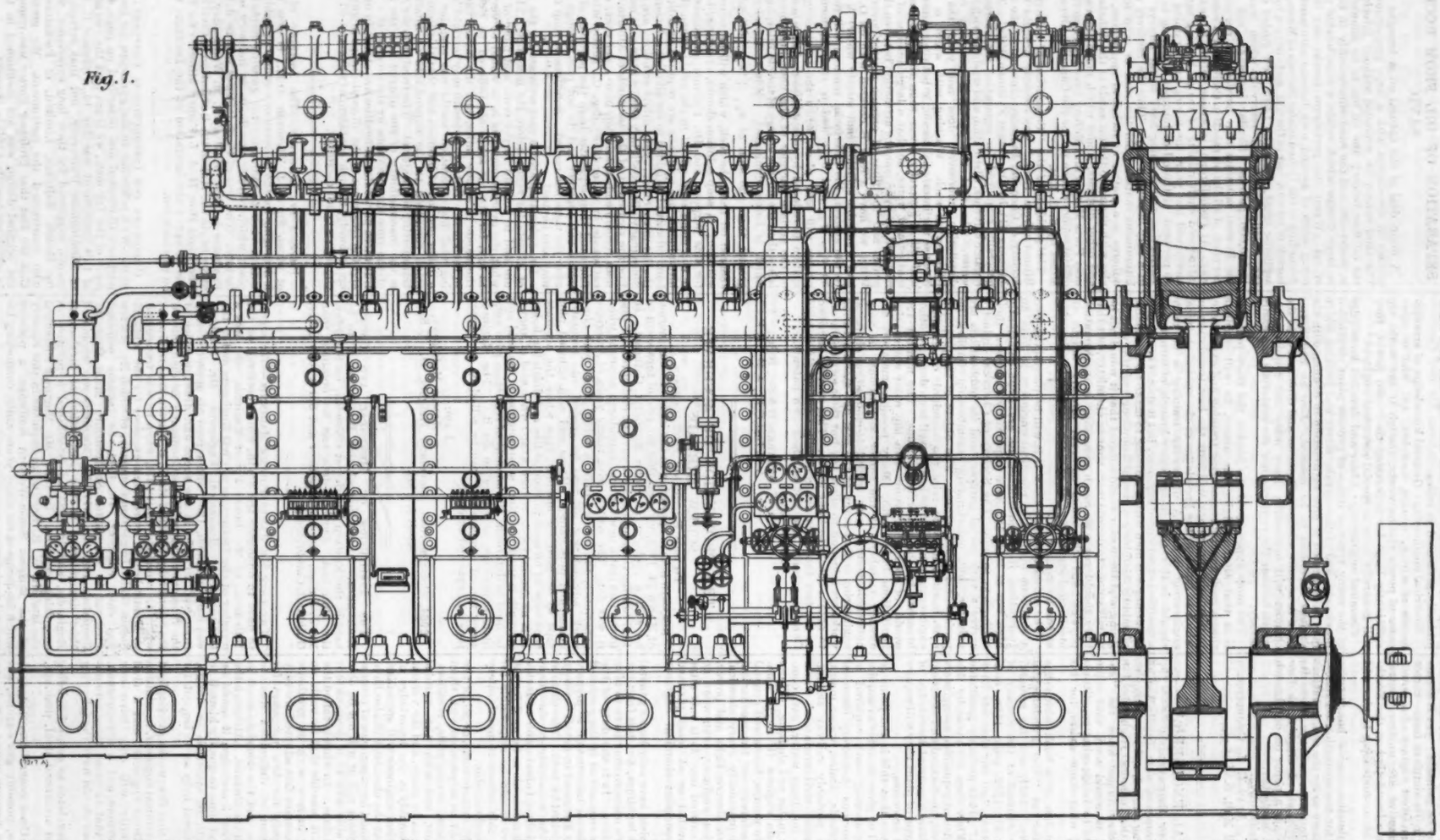
PHYSICS IN INDUSTRY.—The Institute of Physics, of which Sir J. J. Thomson, O.M., is now president, is arranging for the delivery of a course of public lectures with a view to indicating the growing importance and place which physics now holds in industry and manufacture. The first of these lectures will be delivered by Professor A. Barr, of Glasgow, on Wednesday, April 26, at 8 p.m., in the Hall of the Institution of Civil Engineers. The Right Hon. H. A. L. Fisher, Minister for Education, has accepted the invitation of the Institute to preside on this occasion.

GYROSCOPE FOR INSTRUCTIONAL PURPOSES: ADDENDUM.—With reference to the gyroscope for instructional purposes illustrated and described on page 420 of our issue of the 7th inst., we learn that the essential design of this instrument was due to Professor R. C. Porter, of Birmingham University, but that certain improvements, suggested by their long experience, were made by Messrs. Salterns, Limited, of Parkstone, Dorset, who constructed the instrument. We greatly regret that the fact that Professor Porter was responsible for the original design was not mentioned in the article in which we described this instrument.

THE BEARDMORE-TOSI MARINE DIESEL ENGINE.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS, DALMUIR.

Fig. 1.



RECENT marine developments in all systems of propulsion have not lessened the claims of the Diesel engine as a most economical prime mover, although at the present moment the relative prices of oil fuel and coal are such that the greatest economies can only be achieved on those routes where oil may be picked up near to its source, and therefore at a low price compared with that of coal. This, however, is but a passing phase, and the balance of price will swing again in the direction of favouring the Diesel engine. It is, therefore, with considerable interest that we illustrate an example of one of the latest types of Diesel propelling machinery. The "Beardmore-Tosi" marine Diesel engine is the outcome of the experience of the two well-known firms of Messrs. William Beardmore and Co., Limited, of Glasgow, and Messrs. Franco Tosi, of Italy, both names having been associated for many years with the development of internal combustion machinery, and that of the Italian firm more particularly in relation to the Diesel oil engine. The leading features of the design will be apparent from the drawings given in Figs. 1 to 4 on this and the opposite pages, which illustrate the main engines of the single-screw motor ship Pinzon, built by Messrs. Beardmore for Messrs. MacAndrews and Co., Limited, London, and dealt with in the paper on "Diesel machinery for single-screw motor ships," read before the Institution of Naval Architects and reproduced on page 417 of our issue of April 7. The discussion on this paper was reported on page 449 of our last issue.

Discussion and speculation regarding the relative merits of the bewildering variety of types of marine internal combustion engines now being built and projected does not abate, although the four-stroke cycle is still predominant, and is still the favoured type for the average class of merchantman. The "Beardmore-Tosi" engine represents the four-stroke cycle single-acting engine in its latest form, and this engine embodies in its design and construction certain novel features by way of important modifications on the standard Otto cycle of internal combustion. We would refer to the paper we have quoted above for the leading particulars and dimensions of this engine, and will confine these remarks to a description of the more important features which are here illustrated by sectional detail drawings.

Dealing first with those parts which have a bearing on the combustion-cylinder heads, cylinder and liner,

THE BEARDMORE-TOSI MARINE DIESEL ENGINE.

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Fig. 2.

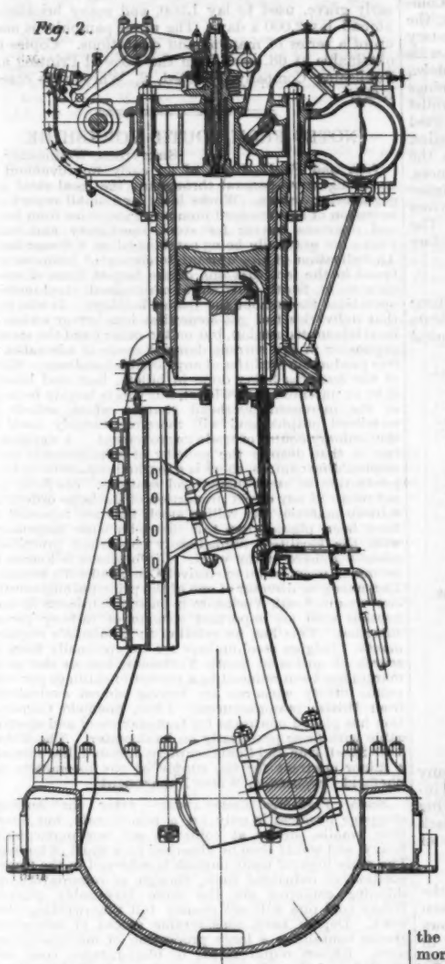


Fig. 3.

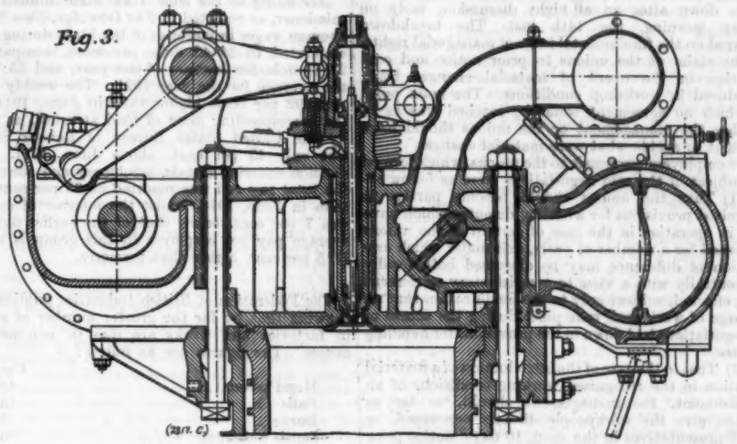
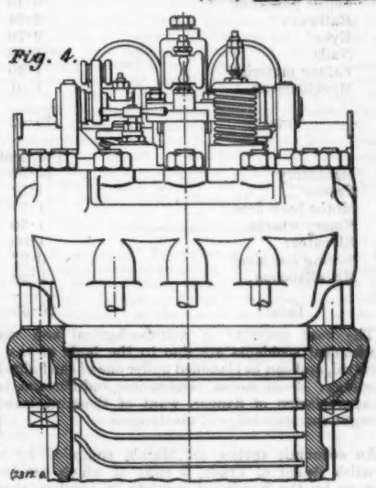


Fig. 4.



it will be seen from Fig. 2 that the cylinder head of box section is attached to the cylinder body by bolts and not by studs, these bolts are of considerable length to reduce stresses, and are attached to a flange on the cylinder top of circular section cored and water-cooled internally. The bolts pass through tubes expanded into the water space of the head. In the head are accommodated the usual number of valves for a four-cycle engine, five in number, inlet and exhaust, fuel admission, starting air and relief. The fuel admission valve is of special design, no packing for the spindle being required. Any leakage with this valve is confined to compressed air and not to compressed air and fuel, as is usual, and can only take place during 40 deg. out of the two revolutions of the cycle. This result is achieved by operating the fuel valve through the usual system of double levers giving an outward opening valve and, by means of the interposition in the driving gear, of a combined tappet and valve, the seating of which is automatically achieved by the pressure of the injection air in the valve casing. In actual practice it is found that there is no leakage whatsoever. The construction of the valve will be clear from the cross section reproduced. The starting air and relief valves are generally of standard design; the springs, however, are carried on ball bearings permitting of these valves, as well as of the other valves in the cylinder head, being rotated on their seats whilst the engine is in operation, which allows of the testing of the operation of the valve and of clearing from the seat any matter which may have lodged there.

Considering next the inlet and exhaust arrangements, which form the most outstanding feature of this design, the two valves operate both for inlet and exhaust, a flap valve serving to direct the exhaust gases out from the cylinder and the induction air into the cylinder. The advantages of this system may briefly be stated. These valves are of only half the normal area, therefore the cylinder head is stronger in this respect. Furthermore, each valve is cooled each cycle by the cool induction air, which must be drawn across its face, and therefore the temperature at which these valves work is only a fraction of the normal and makes for exhaust valve conditions of operation far more easy than has ever before been the case to the extent that dismantling for purposes of regrinding and examination need only be carried out at exceedingly long intervals. Not only are these valves cooled themselves, but the cylinder head, being less perforated by holes, is also better cooled, so reducing temperature stresses there. The water spaces between the valves are much greater than hitherto.

The liner is of novel design in having circular grooves on the outside, around which the water is directed at high velocity, facilitating cooling and preventing the deposit of sand or sludge. The cylinder of strong section, well ribbed, carries the tension stress from the head to the columns. The liner is pressed into the cylinder, being free to expand downwards, and having at the bottom end the usual arrangement for attaining water tightness. The undersides of the cylinders are closed, as is normal in four-stroke cycle practice, so preventing any carbon, unburnt fuel, or lubricating oil from finding its way into the crank chamber there to contaminate the main forced lubricating system. The piston is cooled by fresh water being led in and out by telescopic pipes so arranged that any leakage of water also can only find its way on to the tray or bottom cylinder cover, to be drained off from thence with the unburnt fuel and lubricating oil already mentioned. A stuffing box is provided for the piston to make complete this isolation of the crank chamber. Salt water can equally well be used for cooling the pistons, although fresh water is much to be preferred, if the ship is liable to operate in shallow, sandy or muddy rivers.

In regard to the induction system of the engine, the air may be drawn alternatively direct from the engine-room or from the undersides of the pistons, so that the current of fresh air drawn across this space by the induction, by changing over one small valve whilst the engine is running, may draw any gases from these spaces. Were these gases allowed to enter the engine-room, they would vitiate the atmosphere and make for uncomfortable conditions.

The crosshead slipper connecting rod and water-cooled ahead and astern guides follow accepted forced lubrication marine practice. The only point worthy of special remark in this connection is the fact that the bearing surfaces allowed are probably larger than has hitherto been the case, making for security and the attaining of cool running and minimum bearing wear.

The engine columns of cast-iron are of the usual trestle design. Through bolts are not utilised for the carrying of the tension loads, the castings being suitably designed and of sufficient scantlings to this end. The bottom halves of the main bearing bushes are semi-circular, so that they can readily be turned out for inspection and relining with white metal.

The camshaft is driven from the crankshaft through the usual vertical shaft and spiral gearing. The vertical shaft also serves to drive the fuel pumps, revolution indicator and cylinder force-feed lubricators.

The fuel pumps may be seen in the elevation (Fig. 1), to the right of the control station. For a description of the engine manœuvring gear reference may be made to Fig. 8 on page 419 *ante*. The engine, being of the air-injection type, has two complete blast air services and two bottles, so that for single-screw ships the failure of any pipe joint, &c., does not necessitate stopping the ship. The other service can immediately be opened up. For supplying the air, there are two stage injection compressers at the forward end of the engine driven by an extension of the main crankshaft. From the fulcrum shaft, the starting air and fuel injection air is controlled, valves being operated by cams of suitable profile to the end that the starting and injection air reservoirs and bottles respectively are opened up to the engine at the correct instant during the starting up.

The engine is provided with an ample flywheel permitting of a high degree of flexibility for manœuvring.

INDUSTRIAL LIGHTING.—In the address delivered before the Illuminating Engineering Society on Tuesday, February 28, Mr. Leon Gaster (hon. secretary of the society) drew attention to the importance of good lighting in factories, as an essential to the health and safety of workers, and as a condition of efficient and rapid work. Experience, he said, had shown that there was a close connection between the prevalence of accidents and the lighting conditions, and tests indicated that improvements in lighting led to considerable advances in output, and diminution of spoiled work. Generally speaking the cost of lighting formed only a very small proportion, usually less than 1 per cent., of the costs of production. Expenditure to secure proper lighting was therefore a good investment and should be regarded as a national asset. Ideal conditions should enable work to proceed at night with the same ease and safety as in good daylight, and the necessary conditions had been admirably summarised in the reports issued by the Home Office Departmental Committee on Lighting in Factories and Workshops. The latest of these reports was referred to on page 145 *ante*. The Home Office had for a number of years taken a great interest in industrial lighting, and, in this respect, this country was in advance of the rest of Europe. In discussing legislative requirements, Mr. Gaster pointed out the necessity for the framing of general lighting recommendations, which could readily be carried out, and would be of great benefit both to employers and workers.

INDUSTRIAL NOTES.

THE negotiations which were taking place, as stated in our last issue, between the employers and the other unions outside the Amalgamated Engineering Union, broke down after an all-night discussion, early on Friday morning, the 14th inst. The breakdown occurred on the fundamental issue of managerial rights, on the claim of the unions to prior notice and consultation in the event of material changes being introduced in workshop conditions. The main point on which no agreement could be reached was as to whether the management or the unions should have the right to decide what were material changes.

The employers' proposals to the unions, which formed the subject of the said negotiations were as follow :—

"(1) That the unions should become parties to recognised provisions for avoiding disputes which have been in operation in the case of certain of the unions concerned for a number of years, and under which any question of difference may be discussed both locally and centrally with a view to a satisfactory settlement being effected, subject only to the modification that no stoppage of work shall take place during the course of the negotiations laid down in the provisions for avoiding disputes.

"(2) That in the case of the introduction of a material alteration in the recognised working conditions of an establishment, the management should, so far as possible, give the workpeople directly concerned, or their representatives in the shop, 10 days' notice prior to the institution of the alteration, and that during this period the workpeople concerned, or their representatives in the shop, should have an opportunity of discussing the matter with the management."

The unions, for their part, stated that the employers, whilst willing ostensibly to give prior notice and consultation in regard to the introduction of material changes, claimed the sole right to decide, in the first instance, what were, or were not, material alterations, and as prior notice and consultation would not apply in the case of changes which the employers considered not to be material ones, the effect of the employers' proposals would have been to leave the employers the undivided right to say when prior notice and consultation were to take place.

In regard to the shipyard difficulty, there are still no signs of an agreement being reached in the near future, and in the meantime Continental shipbuilding and ship-repairing firms are taking full advantage of the situation.

It is announced that the men employed in the ship-repairing industry in London are to be balloted on proposals made by the Ship Repairers' Association for a reduction in wages of 5*s.* 6*d.* per week as from the 19th inst., a further 5*s.* per week as from May 31, the remaining 6*s.*, making up the total of 16*s.* 6*d.*, not to be withdrawn before June 21. The ballot is returnable to-day.

In an article published by *The Newcastle Daily Chronicle*, Mr. J. R. Clynes calls the Government to task for "adding another Unemployment Insurance Act to the long list of such Acts, the first of which was passed in 1911." He adds that this new Act "makes provision for the present rates of benefit until June, 1923, and proceeds on the perfectly appalling assumption that the degree of unemployment now existing will remain at the same level for the next fifteen months." According to Mr. Clynes the question resolves itself into this. "Should the unemployed be supported in a state of absolute idleness, or should their support be turned into wages for the performance of some work which they are fit to do in exchange for what they receive." To our way of thinking, this is simply a number of mere phrases added to an already considerable quantity on the same topic. Mr. Clynes does not appear to us to have any solution to offer. He simply asks "whether the British reputation for common sense has deserted those who are vested with authority to deal with the problems." The article is most incomplete. If he specified who are "those vested with authority" in the present circumstances, it might be possible to go deeper into the matter. The Government are probably meant; but what, may be asked, can the Government do, and do without any untoward expenditure, in presence of a large and constantly increasing proportion of men who, being in receipt of doles, will not work on any account, men who, when offered a casual job at, probably 2*l.* 10*s.* per week, refuse it, preferring to remain idle on 35*s.* The said men admit this freely. The situation is a most involved one, and one which will not be solved by merely asking questions; its solution should come quickly, for we are fast becoming a nation of beggars. It is to such men—and they are not difficult to find: there are hundreds in every parish or borough—that the Parliamentary Labour Party, of which Mr. Clynes is chairman, should preach, thereby showing or trying to show that "we are *not* losing our reputation for common sense."

According to the New York State Industrial Commissioner, as reported in *The Iron Age*, New York, the average wages in factories of the State during January amounted to 24·43 dols. per week, compared with 27·61 dols. for January of last year, and 25·72 dols., the average for the year 1921. The weekly earnings were 92 per cent. higher than in June, 1914, whilst the corresponding price of food at retail, as reported by the United States Bureau of Labour Statistics, was only 43 per cent. above June, 1914. In the division covering metals, machinery and conveyances, the total pay roll was reported as 65 per cent. higher than in June, 1914, whilst the number of employees was 7 per cent. below that of the earlier date. The average pay per employee in this group is therefore 77·5 per cent. higher than formerly.

The Federation of British Industries publish returns showing that by far the greater number of accidents in factories and works are due to non-mechanical causes. The figures are as follow :—

	Per Cent.
Hand labour	40·97
Falls	15·11
Burns	7·10
Septic poisoning	6·16
Railways	3·54
Eyes	2·70
Nails	1·43
Falling material	1·40
Miscellaneous	1·01
Total	79·42

	Per Cent.
Machinery	10·92
Cranes	1·81
Motor back-fires	1·73
Emery wheels	1·30
Elevators	1·00
Sewing machines	0·97
Miscellaneous	2·85
Total	20·58

The vast majority of non-mechanical and many mechanical accidents are due to the fault of the individual, and can be classified under one of the following headings: Recklessness, carelessness, indifference, lack of appreciation of danger, want of thought, lack of thought and knowledge of the dangers.

An economic review for March, compiled by the Swedish Board of Trade, a copy of which has been sent us by the Swedish Consulate in London, shows that in Sweden, on February 28, the unemployed in cities numbered 62,000 and in the country 94,000, a total of 156,000, of whom 65,400 were granted Government relief. The review states that large cuts have been made in the scales of wages, but, it adds, a further lowering in wages is still necessary to enable the Swedish industries to carry on. High taxes and high railway carriage rates also retard business. Considerable reductions recently made in Government expenditure have done much to lower taxation; in regard, however, to railway rates, these, on an average, still exceed pre-war levels by 250 per cent. for full wagon loads and by 325 per cent. for small deliveries.

A pamphlet which, it is greatly to be hoped, will reach a wide circulation, is entitled "Labour Trusts," and contains numerous notes based on a lecture given at St. Stephen's Club, Westminster, on December 14 last, by Mr. Theodore Rich. The pamphlet would deserve to be reproduced in full, but owing to its scope (it covers 32 octavo pages), we must limit ourselves to only a few examples. Thus, in regard to Education and Economics, "the working classes are taught that the green colour in a blade of grass is due to chlorophyl, but not that we must either export commodities in competition with the world in order to get food, or starve." Then under another heading it is stated that "in some parts of Scotland, workers have been forbidden to discuss trade matters with their employers, except in the presence of a delegate or shop steward; the reason is obvious, the worker might learn too much. When leaders like George Barnes and Colonel Ward begin to realise some of the economic factors of life, they are denounced for selling the worker to the capitalist, and are at times howled down; they must not hand on to the workers what they have learned." The real social reformers, the author points out, were men like George Stephenson, Watt, Humphrey Davey, Faraday and Captain Cook, who did very much more for the workers than say Tom Mann, Ernest Bevin or Sydney Webb, and other much advertised trade unionists or self-styled social reformers. He also calls attention to the constant cry against slums, and points out that, at the same time, a bricklayer is not allowed to lay more than 300 bricks a day, when his father, without driving himself to an early grave, used to lay 1,000, and many bricklayers abroad lay 2,000 a day. The whole pamphlet is made up of a series of maxims and quotations. Copies are obtainable at 6d. each from the Boswell Printing and Publishing Company, Limited, 2, Whitefriars Street, E.C.4.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Hope of an early improvement is becoming more general throughout the local steel and engineering trades. Works large and small report the accession of an increased number of inquiries from home and overseas buyers for steel, machinery and tools. Prices are gradually being established on a firmer basis. An indication of the upward tendency of business was found in the fact that one of the largest firms of steel-makers in South Yorkshire maintained steel-melting operations throughout the Easter holidays. It was true that deliveries had got somewhat into arrear owing to local labour dislocation, but on the other hand the steady expansion in the current demand made it advisable to free production facilities of any possible handicap. Much of the business being done in billets, bars and blooms is at an unremunerative level, but this is largely because of the increased overhead charges which attach to restricted output, and will therefore remedy itself in the ordinary course of trade improvement. A significant fact is that despite the paucity of requirements from shipbuilding centres, there is a marked expansion in local production of steel ingots and castings. Sheffield has not received any direct proportion of the large orders for railway material and rolling stock that are reported to have been placed, but this district's close association with the localities immediately concerned practically ensures a share of the work. Big business is known to be under negotiation exclusively on Sheffield's account. The managing director of one of the principal engineering concerns in South Yorkshire is on the Continent in connection with an important scheme of railway reconstruction. This has no relation to Rumania's requirements. Belgian steel-makers are exceptionally keen in search of orders in South Yorkshire, but as the price margin has been reduced to a matter of shillings per ton, public utility concerns are buying almost exclusively from British manufacturers. Thus, Sheffield Corporation has placed contracts for tramway steel and electric cable with firms practically on its doorstep. The Ebbw Vale Steel, Iron and Coal Company, Limited, has secured a minor contract for the supply of one locomotive to Sheffield Corporation Water Department.

South Yorkshire Coal Trade.—After the holiday stoppage business is only on a minor scale, but apart from smalls, stocks at collieries are not particularly heavy, and would soon be absorbed by a spurt of buying. The more hopeful trade outlook is reflected in the firmer position of industrial fuels, though as regards orders, shipping collieries are the more favourably placed. House coal pits will not resume full time-working this week. Depots have considerable stocks of secondary grades containing a large proportion of manufacturing sorts. Export requirements of blast-furnace coke are smaller, and there is renewed weakness in slacks, following the pre-holiday pressure. Quotations :—Best branch handpicked, 38*s.* to 39*s.*; Barnsley best Silkstone, 36*s.* to 37*s.*; Derbyshire best brights, 32*s.* 6*d.* to 34*s.*; Derbyshire best house, 31*s.* to 33*s.*; Derbyshire best large nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Derbyshire best small nuts, 17*s.* to 19*s.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; rough slacks, 14*s.* to 15*s.*; nutty slacks, 8*s.* to 9*s.* 6*d.*; smalls, 2*s.* 6*d.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Output of Cleveland pig-iron continues to be well taken up, and indeed some descriptions are so scarce as to be almost unobtainable, the shortage being most marked as regards No. 1 and forge qualities. With many foundries idle, and others only partially employed, home needs are on a very moderate scale, but there is rather more inquiry from abroad. Makers continue to take a firm stand and adhere to the following rates for export as well as for home consumption :—No. 1 and siliceous iron, 95*s.*; No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 85*s.*; and mottled and white, 80*s.* As a firm favourably placed for shipment to Scotland had, on the f.o.b. price, an advantage over other firms, makers have agreed to a fixed figure of 96*s.* 8*d.* f.o.t. Grangemouth for sales to customers beyond Tweed.

Hematite.—Whilst business in East Coast hematite is hardly so brisk as it has been, demand, on both home and foreign account keeps fairly good. Producers may be displaying more keenness to secure orders, but they are far from being disposed to make price concessions; some firms, in fact, showing inclination to slightly advance quotations. It is understood that a good deal of the iron going to Hamburg is going on to Austria to cover German commitments to that country. The f.o.t. and f.o.b. quotations are fully 97*s.* for mixed Nos. and 98*s.* for No. 1.

Blast Furnaces in Operation.—The number of blast furnaces in operation on the North-East Coast now

stands at 29, of which 5 are making Cleveland pig-iron, 15 are producing hematite, and 9 are turning out other descriptions of iron. An idle furnace is this week being re-kindled on foundry iron, the output being for the owner's foundry. It is stated that, notwithstanding high cost of transit, Northamptonshire ore from the owners' mines will be exclusively used at this furnace.

Foreign Ore.—There is not much change in foreign ore. Transactions continue small, and the Bilbao strike practically stopped all dealings in Spanish sorts, so that the 27*s.* c.i.f. quotation for rubio is more or less nominal. A few sales of Mediterranean ores at round about 22*s.* c.i.f. are reported.

Coke.—Local consumers of blast-furnace coke are reluctant to pay rates asked, but it is difficult to place orders for medium Durhams at below 28*s.* delivered.

Manufactured Iron and Steel.—In one or two branches of these industries, possibly, inquiry shows some slight improvement, but generally the situation is still very unsatisfactory, and there is little to indicate early material change for the better. Export business can be put through at below the following quotations, which rule for home trade:—Common iron bars, 12*l.*; iron rivets, 14*l.*; soft steel billets, 7*l.* 10*s.*; medium steel billets, 8*l.* 15*s.*; hard steel billets, 9*l.* 5*s.*; steel boiler plates, 14*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy sections of steel rails, 9*l.* 10*s.*; fishplates, 14*l.* 10*s.*; and corrugated galvanised sheets, 16*l.* 5*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The volume and value of cargo exports of coal in March from South Wales showed an increase over the February returns. Exports from the leading ports totalled 2,149,888 tons, an increase of 396,174 tons, while the proceeds amounted to 2,541,157*l.*, an increase of 528,523*l.* Large steam shipped from South Wales amounted to 1,422,047 tons, or 400,000 tons more than in February, while the average declared f.o.b. selling price at 25*s.* 10*d.* per ton showed an increase of 11*d.* Steam smalls shipped totalled 565,320 tons, an increase of 65,000 tons, and the average value at 17*s.* 9*d.* per ton showed an improvement of 6*d.* The volume and value of exports in February and March is shown below:—

—	February.		March.	
From—	Tons.	£	Tons.	£
Cardiff ..	1,135,411	1,297,063	1,435,597	1,728,674
Newport ..	354,989	397,208	419,263	485,350
Port Talbot ..	123,820	123,430	153,014	160,920
Swansea ..	139,494	194,933	142,014	171,213
Totals ..	1,753,714	2,012,634	2,149,888	2,541,157

The detailed official returns show that the proceeds from the sale of steam large and small coals was higher in March than in February, but that the improvement was largely discounted by a fall in the price obtained for steam throughs and a big reduction in the value of anthracite coals. In respect to steam small shipped from Cardiff the average of 17*s.* 7*d.* compares with 16*s.* 6*d.* in February, large 26*s.* 3*d.* against 25*s.* 4*d.*, and throughs 20*s.* 11*d.* against 21*s.* 4*d.* Steam large shipped from Swansea averaged 25*s.* 11*d.* against 25*s.* 6*d.*, smalls 15*s.* 1*d.* against 19*s.* 5*d.*, and throughs 21*s.* 3*d.* against 19*s.* 8*d.* Anthracite large shipped from Swansea averaged only 35*s.* 10*d.* compared with 46*s.* 9*d.* in February and 57*s.* 1*d.* in January, while small averaged 19*s.* 6*d.* compared with 23*s.* 3*d.* in February and 33*s.* 10*d.* in January. There was thus a fall in the price of large of 21*s.* 3*d.* compared with January and of 14*s.* 4*d.* in the value of small. Steam small exported from Newport averaged 19*s.* 2*d.* compared with 19*s.* 1*d.* in February, throughs 21*s.* 4*d.* against 21*s.* 5*d.*, and large 24*s.* 9*d.* against 23*s.* 11*d.*, while that shipped from Port Talbot in the case of smalls averaged 15*s.* 1*d.* compared with 19*s.* 5*d.* in February, throughs 21*s.* 3*d.* against 19*s.* 8*d.*, and large 25*s.* 11*d.* against 25*s.* 6*d.* The average price of steam coal shipped from Cardiff and Swansea in the past three months with comparative figures for March, 1913, September, 1920, and December, 1921, is given in the following table:—

Month.	Cardiff.			Swansea.		
	Small.	Through.	Large.	Small.	Through.	Large.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
March, 1913 ..	11 10	14 7	16 11	11 5	11 1	17 3
Sept., 1920 ..	80 1	99 11	97 2	71 1	90 11	79 2
Dec., 1921 ..	17 4	22 4	26 10	22 7	20 10	27 5
Jan., 1922 ..	16 11	21 6	26 10	17 4	20 2	27 0
Feb., 1922 ..	16 6	21 4	25 4	19 5	19 8	25 6
March, 1922 ..	17 7	20 11	26 3	15 1	21 3	25 11

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

General Trade.—The state of trade in general throughout the country has reached a very low level, and in few industries can any signs of improvement be noted. All are affected directly or indirectly by the present labour troubles, and whenever any large body of workers is locked out, or is on strike, other trades very soon feel the effects. The influence of the Clyde, with its numerous shipyards and engineering shops, is very far-reaching, and the conditions prevailing there now are telling their tale all over the country. With so much total unemployment and so many thousands of others on short time the spending power of the country has greatly diminished and buyers cannot do otherwise than buy from hand to mouth.

Scottish Steel Trade.—Depression continues in the steel trade of Scotland, and the outlook is not yet any better, in fact it is rather worse with the failure in the negotiations for a settlement of the trouble in the engineering and shipbuilding trades. The demand for steel material of all kinds has become very restricted, and in most of the works where operations are still going on only the minimum amount of plant is being worked. The black sheet makers are in none too good a position at present. Orders recently booked are near completion and fresh contracts are very scarce. Inquiries from abroad are fair, but buyers are not giving out orders on the old wholesale scale, and are only placing small lots. The general export trade all round is of the latter category. The following are the current prices:—Boiler plates, 14*l.* per ton; ship plates, 10*l.* 10*s.* per ton; sections, 10*l.* per ton; and sheets, 11*l.* 15*s.* per ton, all at Glasgow stations. The export quotation for ship plates is 9*l.* 5*s.* per ton, and for angles, 8*l.* 10*s.* per ton.

Malleable Iron Trade.—No change of any moment has taken place in the malleable iron trade of the West of Scotland during the past week and very dull conditions prevail. Little fresh business has accrued from the recent reduction which brought "crown" bars down to 11*l.* per ton, delivered Glasgow, but producers are still hopeful of securing additional business before long. Export is quiet, and the price is round 10*l.* 15*s.* per ton.

Scottish Pig-Iron Trade.—The conditions ruling in the pig-iron trade of Scotland are indeed very bad, and even the output from the small number of furnaces in blast is not being cleared away. Every possible inducement has been given to consumers, but withal a certain amount of iron is accumulating. Buyers are being constantly pressed, but when they are without an outlet themselves they are not disposed to carry stock, and prefer to risk the market. Not only is the home demand very poor, but export has also fallen away. Hematite is called 5*l.* 5*s.* per ton, delivered at the steel works, with No. 1 foundry iron 4*l.* 17*s.* 6*d.* per ton, and No. 3, 4*l.* 12*s.* 6*d.* per ton, both at makers' works.

THE SURVEYORS' INSTITUTION.—Acting under their powers under by-laws 46 and 52, the council have elected Mr. John McClare Clark, senior vice-president, of Haltwhistle and Hexham, Northumberland, as president for the remainder of the Institution session, in place of the late Mr. J. H. Sabin. The council have set up a Special Committee to consider the position which is likely to arise in June, 1923, on the Rent Restrictions Acts ceasing to operate, and to report whether any action on the part of the Institution is called for in recommending a renewal or otherwise of the provisions of the Acts or any part thereof. Sir Edgar Harper has been nominated to represent the Institution on the Governing Body of the City of London College in place of the late Mr. J. H. Sabin.

INSTITUTION OF CHEMICAL ENGINEERS.—The Provisional Committee of the Proposed Institution of Chemical Engineers held meetings on Wednesday, March 22, and Wednesday, April 5, at 166, Piccadilly, London, W. Mr. W. J. U. Woolcock, M.P., occupied the chair at the first meeting, and Sir Arthur Duckham presided at the second. At the first meeting a letter was read from the President of the American Institute of Chemical Engineers, proposing that the American Institute print in its Year Book the names and addresses of all the members of the English institution, the English institution, on its side, to print, in its year book, the names and addresses of the members of the American body. This would enable any American member, when visiting England, to easily get in touch with members of the English institution and, in a similar way, be of use to English members when visiting the United States. All members in good standing in the English institution also to have all the privileges of regular members of the American institute, except voting. The same privileges would be extended by the English institution to members of the American institute visiting England. Both institutions would exchange publications. It was agreed that the statutory minimum of seven signatories be adopted in the first instance. Nominations were made of gentlemen both of the Provisional Committee and the Advisory Committee, and a ballot was taken, and the following gentlemen were elected as signatories to the documents: Sir Arthur Duckham, Mr. C. S. Garland, Professor J. W. Hinchley, Mr. W. Macnab, F.I.C., Mr. J. Arthur Reavell, Mr. F. H. Rogers, Mr. H. Talbot. At the April meeting it was further agreed that the seven signatories should be the first associate members of the institution. A small committee was elected to meet a similar committee of the Institute of Chemistry to discuss informally the new institution. Other steps were taken to ensure the utmost amiability with all similar scientific and technical bodies. It was also agreed, that until the first general meeting, when a properly constituted council could be elected, that the Provisional Committee should act as the first council of the institution, the seven signatories being the legal representatives. The solicitors were requested to take the necessary legal steps for the registration of the institution. It was then decided that the inaugural meeting of the body be held on Tuesday, May 2.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 21, at 8 p.m., at Caxton Hall, Ordinary Meeting, "Condenser and Choke Coil Protective Apparatus," by Mr. S. A. Stigant, A.M.I.E.E. (Member).

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, April 21, at 7.30 p.m., at the Institution of Mechanical Engineers, Storey's Gate, London, S.W. Mr. J. R. Smith, A.M.I.E.E., chief electrical engineer of Messrs. J. and E. Hall, Limited, Dartford, will read a paper, to be illustrated by lantern slides, dealing with "Electricity in a Machine Shop."

THE INSTITUTE OF TRANSPORT.—Friday, April 21, at 5 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. Lecture, "The Operation of a Large Tramway Undertaking, with Reference to Capacity and Cost under Given Conditions," by Mr. J. K. Bruce, Member.

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, April 22, at 7.15 p.m., in the Lecture Hall, of the Hull Municipal Technical College, a lecture will be delivered on "Marine Geared Turbines," by Mr. A. T. J. Kersey, M.I.A.E., A.M.I.Mech.E. Chairman, Mr. G. F. Riordan, B.Sc., M.I.Mech.E.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS: LONDON.—Saturday, April 22. General Meeting cancelled.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, April 22, at 3 p.m., at the Royal Technical College, George-street, Glasgow. Forty-fifth annual meeting Papers to be discussed: "The Operation of Mine Fans in Parallel," by Mr. Joseph Parker, B.Sc.; "Pipe Friction and Pump Efficiency," by Mr. William Brazenall; "The Characteristic Curves of Fans and their Application to Predetermine the Output and Efficiency of Fans Working Singly and in Parallel on Various Resistances," by Mr. Joseph Parker, B.Sc. Demonstration of "Safety Devices for Cages," by Mr. Thomas L. Rae.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 25, at 6 p.m., Annual General Meeting of Corporate Members only, to receive the Report of the Council, and to elect the Council and Auditors for the ensuing year.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 26, at 8 p.m., at Royal Institution, Colquitt-street, Liverpool, Annual General Meeting. Thursday, April 27, at 7.30 p.m., Students' Meeting. Paper on "The Uniflow Steam Engine," by Mr. E. Cockshutt.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, April 26, at 2.30 p.m., the Fifth Annual General Meeting in Mappin Hall, Applied Science Department, The University, St. George's-square, Sheffield. Presidential Address: "The British Glass Industry: Its Development and Outlook." Address on "The Mediæval Glass of York Minster," by the Dean of York. The annual dinner will be held at the Royal Victoria Station Hotel on the same evening.

THE OPTICAL SOCIETY.—Thursday, April 27, at 7.30 p.m., at the Imperial College of Science and Technology, South Kensington. Lecture on "The Mechanical Construction of the Microscope from a Historical Standpoint," by Professor Alan Pollard, F.Inst.P. (illustrated by exhibits from the collection in the Science Museum, Kensington).

THE NEWCOMEN SOCIETY.—Wednesday, April 27, at 5 p.m., at Caxton Hall, Westminster, the following short papers will be presented: "A Note on Brunton's Walking Engine, 1813," by Mr. L. St. L. Pendred, M.I.Mech.E.; "A Note on Heaton's Steam Carriage, 1828," by Mr. A. Titley, M.I.Mech.E.; "Gurney's Railway Locomotives," by Mr. E. A. Forward, A.R.C.S.

THE ILLUMINATING ENGINEERING SOCIETY.—Thursday, April 27, at 8 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, London, joint discussion with the Royal Society of Medicine (Sections of Surgery and Ophthalmology) on "The Use of Light in Hospitals" (including the illumination of hospital wards and operating tables and some other special applications of light).

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 27, at 6 p.m., "Protective Apparatus for Turbo-Alternators," by Mr. J. A. Kuyser, Member.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 28, at 9 p.m., a discourse will be delivered by Mr. Arthur Harden, D.Sc., F.R.S. The subject is "Vitamin Problems." Afternoon Lectures, at 3 p.m.: Tuesday, April 25, Sir Arthur Keith, M.D., LL.D., F.R.S., M.R.I., Fullerian Professor of Physiology, R.I., on "Anthropological Problems of the British Empire. Series II.—Racial Problems of Africa (Lecture I); Wednesday, April 26, Professor D. H. MacGregor, M.A., M.C., on "Industrial Relationships: (I) The Historical Interpretation"; Thursday, April 27, Mr. Edwin H. Barton, D.Sc., F.R.S., on "Audition and Colour Vision: (I) The Resonance Theory of Audition."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 28, at 6 p.m., at the Institution, Storey's Gate, St. James's Park, S.W., "An Account of Some Experiments on the Action of Cutting Tools," by Professor E. G. Coker, D.Sc., F.R.S., of London, Member, and Mr. K. C. Chakko, D.Sc.

ASSOCIATION OF RAILWAY COMPANIES' SIGNAL SUPERINTENDENTS AND SIGNAL ENGINEERS.—The sixty-fourth Conference of the above association will be held at the Railway Clearing House, London, on Thursday, May 4.

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(*For Description, see Page* 485.)

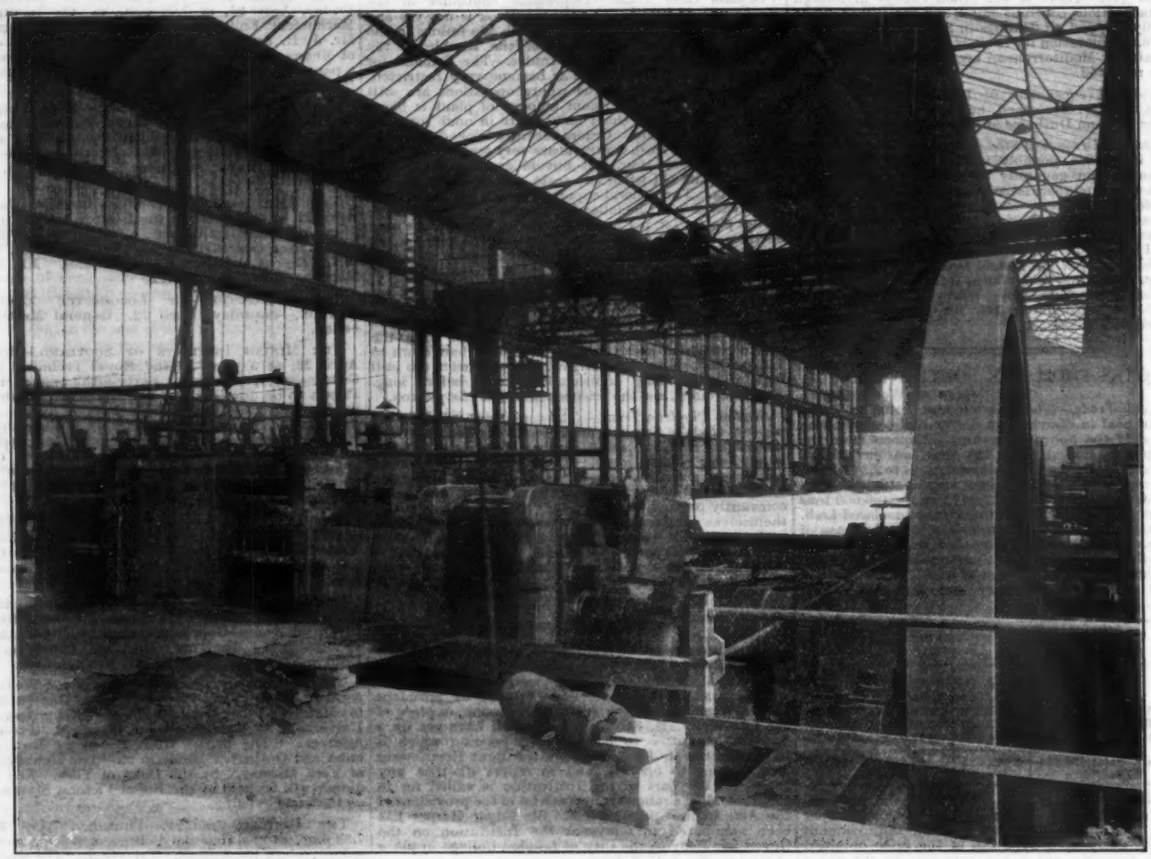

FIG. 1. ROUGHING MILL.

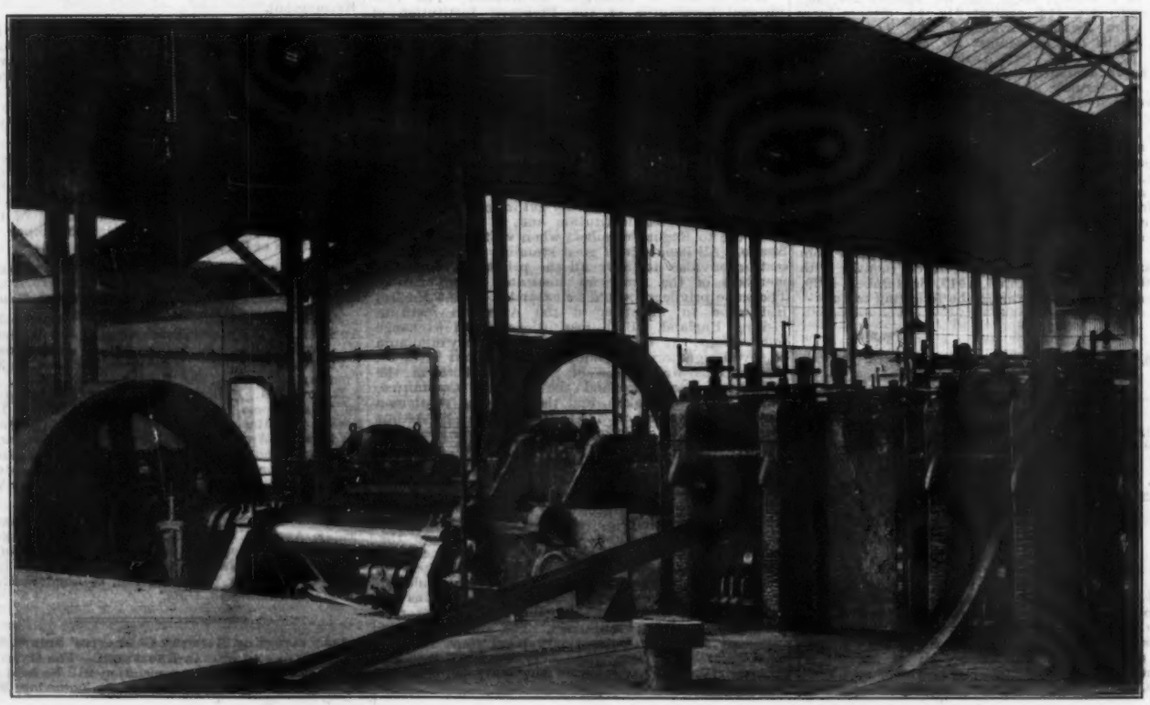

FIG. 2. FINISHING MILL.

ENGINEERING.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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Two-Page Plate.—DOUBLE TWO-HIGH ROLLING MILL FOR THE IMPROVED STEEL COMPANY, LIMITED, TIPTON

ENGINEERING.

FRIDAY, APRIL 21, 1922.

THE MANUFACTURE OF STEAM.

THE deplorable inefficiency with which a large number of boiler plants are operated is frequently commented upon. Mr. David Brownlie's figures showing that the average working efficiency of industrial boilers is below 60 per cent. have never been seriously questioned, and indeed they can hardly be doubted in view of the wide range and detailed nature of the investigations on which they were founded. If 60 per cent. then fairly represents the average efficiency, the waste of fuel at many of the plants may be left to the imagination. We do not wish to labour the point that a terrible amount of coal is annually wasted, nor that such waste, together with the useless labour involved in burning coal needlessly, is a source of heavy loss both to the individual and the nation. The facts are admitted, and it is more profitable to suggest a reason and a remedy than to indulge in lamentations. In the first place it may be said that the chief cause of inefficiency is rarely to be found in defects in the main equipment or lay-out of the plant. Boilers and boiler-settings of various types are practically standardised, and though some designs may be better than others, the difference is negligible in comparison with the variation of the operating results obtained. Nor is a low efficiency to be cured by decorating the boiler room with every kind of scientific apparatus on the market. Such apparatus has its place, but by itself it will no more save coal than a clinical thermometer or a stethoscope will keep a man in health.

The real reason why many boiler plants are so wasteful is simply because they are so badly operated and maintained. The management tolerate these conditions because nobody realises how bad things really are, or indeed that there is anything at all to complain about. Were the boiler plant regarded as what it really is, namely, a self-contained department which manufactures steam by the consumption of coal, water and labour, and were a constant check kept upon the amount of raw material in the form of coal which is used to manufacture a certain quantity of steam, inefficiency of operation would automatically be brought to light. No ordinary manufacturing business could be run successfully on the principle that the manager had done his duty so far as material was concerned by ensuring that there was always sufficient in stock to meet current needs. The quantity converted into saleable products would be constantly checked against the quantity issued from the stores, and the amount of scrap and the unaccounted for balance would be matters for close scrutiny. If this is necessary in the case of articles made from iron, steel or timber it is much more necessary in the case of steam, where the raw material coal not only constitutes an overwhelming item of expense but vanishes into empty air equally whether used efficiently or otherwise. The only function of coal in a boiler-plant is to evaporate water, and surely the first step towards economy of coal is to take note of the evaporation obtained per pound of coal. When, towards the end of the war, there was an acute coal shortage in the United States, the American Coal Controller gave priority of supply, other things being equal, to those plants equipped with coal scales and water meters. His action was entirely sensible, being dictated by the belief that those who appreciated what every pound of coal ought to do would burn most economically the limited supplies available.

Those unfamiliar with steam plants will hardly credit the fact that it is quite the exception to find boiler houses in which any proper check is kept upon the coal consumption in its relationship to the steam manufactured. Yet this, unfortunately, is the case. From an examination of some 2,000 boilers Mr. David Brownlie stated before the Institution of Mechanical Engineers last summer that it might be taken that less than 10 per cent. of the boiler plants in the country had feed-water meters, and that less than 1 per cent. possessed steam meters. It is probably accurate to say that boiler-room coal scales are nearly as rare as steam meters. With such a lack of essential measuring devices is it to be wondered at that the operators are without the powerful incentive to efficiency which arises from an accurate knowledge of what they are doing and therefore whether they are improving their results or otherwise. Their duty is to make as much steam as possible for a pound of coal, and without the records of how much they are making, the CO_2 percentages, flue gas temperatures, draught gauge readings, &c., are merely indirect items of interesting information. It is steam which is wanted, not CO_2 or cool flue gas. The value of perfect combustion conditions in the furnace may be neutralised by dirty boiler tubes, and conversely a clean boiler will waste fuel if the fires are flooded with excess air. Nothing but the overall figures as to how much steam is made per pound of coal of a known quality will really measure the efficiency of operation, and if as much attention were given to this fundamental fact as is often bestowed on partial or indirect guides to efficiency, steam production would be materially cheaper. Occasional boiler tests are of little practical value, for half an hour after the test is over the boiler may be operated in a deplorable manner. What is wanted is a definite knowledge of the operating results for every previous day or shift, depending upon the nature of the plant, so that any falling off in efficiency may be investigated while the facts are fresh.

It is probably safe to say that even such elementary records are not properly kept in one boiler plant in a hundred. Of the seventy or so public generating stations which serve Greater London, we very much doubt whether ten could be found in which the quantity of coal burnt and of water evaporated on each of the shifts are known. If such a state of affairs exists in important plants, where one could reasonably expect efficient operating methods, is it to be wondered at that the private boiler plants which are auxiliary to some manufacturing or heating purpose are generally in a bad way. A difference of 5 per cent. between the steam consumptions of two turbines is considered quite a lot, and the same engineer who will cheerfully pay a much higher price for the more economical machine will unknowingly tolerate his boiler plant being operated in a manner which wastes very

many times the amount of coal which he expects the turbine to save. He will also equip the machine with gauges, condensate-recorder, &c., all for the purpose of detecting the cause or the fact of any increase in the steam consumption per kilowatt-hour generated. Were the same care devoted to the immediate detection of any increase in the quantity of coal burned per pound of steam generated, it would be far more fruitful in keeping down the cost of power.

There is no lack of apparatus on the market, either for measuring the coal as it is fed into the furnaces, or for measuring the evaporation which it effects. Meters, of course, cost money, but on the other hand so does coal, and the initial expense of an adequate meter installation is soon more than saved by the greater economy which its records make possible. Considerations of initial expense are not, however, generally put forward as an excuse for the lack of any proper provision for recording the working performance of the boilers. A very frequent objection is that different qualities of coal vary so widely that an evaporation figure which would be an excellent one for one class of coal would correspond to a very mediocre efficiency with better coal. While this is, of course, true in itself, it can hardly be regarded seriously as a reason for feeding coal and water into the boilers without any check on either. When a plant is nominally running on one class of coal, it is quite easy to set an evaporation figure which ought to be attained, and if the operating conditions are constant, any failure to reach the standard evaporation would give grounds for suspicion that the coal was not up to the mark. At any rate, the evaporation records would give the engineer a notification, which he would not otherwise have, that something was wrong. Furthermore, where different classes of coal are being burnt, either in successive consignments or as a mixture, the engineer may reasonably be expected to know what he is burning on any shift, and he can then check his evaporation against the standard he decides on for that particular class or mixture.

The other objection sometimes raised against the utility of obtaining evaporation figures for every shift, is that even when burning a uniform quality of coal, and maintaining equally good operating conditions, the evaporative efficiency of the boilers will vary with the demand for steam during the shift in question. Hence when the output was small the firemen might be unjustly blamed for figures, which considering the smallness of the load, were really creditable ones. There is something in this contention, at first sight, but the difficulty, which only occurs when the outputs are materially different, is very easily overcome. It was shown in these columns several years ago that if the total water consumption of a boiler-plant per shift were plotted against the total coal consumption for the same shifts, the points would fall about a straight line. The greater the variation in the output per shift the more easily is the best position for the line determined. The working records of a week or two are sufficient to establish its position with all the accuracy practically needed, and it then forms a criterion with which the evaporation figures may be properly compared whatever the output of a shift may be. Suppose, for example, that the line, as thus determined for some particular plant were found to be that represented by the equation $W = 7{\cdot}5\,C - 14000$ in which W and C denote respectively the number of pounds of water evaporated and of coal burnt during any shift. From this equation it is easy to find the standard evaporation which should correspond with any coal consumption, and it follows that, in the station in question, when 20,000 lbs. of coal are burnt per shift, the standard evaporation would be 6·8 lbs. of water, as compared with 7·22 lbs. of water per pound of coal when 50,000 lbs. of coal are consumed in the same time, the difference between these figures being due entirely to the difference in the load. The standard evaporation for any load may be similarly determined, and the performance of the boilers therefore may be appraised independently of the output on any particular shift.

Our object, however, is not to discuss the details of boiler-house management nor the analysis of the records, but rather to emphasise the fact implied in the title of the article, namely, that steam is a manufactured product, and until it is more generally regarded as such there is little hope for much greater economy in its production. When the manager of a boiler-plant buys coal, he should buy it with the idea of getting a certain weight of steam for every pound of coal purchased, and he should maintain at least a daily check upon the operation of the plant to see that this aspiration is realised. With the actual evaporation figures before him he will not only be able to purchase coal in the light of reliable information as to its true value to himself, but if the evaporation figures fluctuate he will have cause to make inquiry as to whether the quality of the coal is being maintained or whether the plant is being operated carelessly. Without such records he is practically in the dark, and has to act upon opinions, estimates and other poor substitutes for proper evidence which would never be accepted with regard to other important manufacturing questions. The whole weight of experience goes to show that until every boiler plant has to stand on its own feet and produce so much steam for every pound of coal it handles, coal will be wasted, labour and fuel cost will be high, and a sustained operating efficiency will be impossible to realise.

BLAST FURNACES AND CUPOLAS.

THE first paper to be read before the Iron and Steel Institute in 1869, a few months only after the foundation of the Institute, was one by Sir Lothian Bell, entitled "The Development of Heat, and its Appropriation in Blast Furnaces of Different Dimensions." The paper itself, apart from the discussion upon it, covered close upon 100 pages of the Institute's proceedings and reviewed the working of the blast furnace in very great detail. The paper, in fact, may be considered as a standard for reference even now. During the half century which has elapsed since, pig-iron has been manufactured by millions of tons and has been transformed successfully into millions of tons of iron and steel. Great progress has been made in the utilisation of the other materials which proceed from the blast furnace, formerly reckoned as waste, and now considered as by-products, such as the slag, and more especially the gas. But in regard to the actual working of the blast furnace itself as a pig-iron producer, on reading the communications which are made periodically to technical societies, dealing with this "prime mover" in ferrous metallurgy, progress does not appear to have been quite so great. These points were brought to mind by reading the latest communication on the subject to reach us, a paper by Mr. J. E. Fletcher, past president of the Staffordshire Iron and Steel Institute, entitled "The Blast Furnace and the Foundry Cupola," read before that Institute on March 25.

The comparative lack of real progress is there stated to be due to the fact that "in the ideal blast furnace operated so as to produce iron of uniform composition, the ores, fuels and fluxes used are not of regular character with respect to physical, chemical and mineralogical composition, and are not uniformly charged at the correct rate." In other words, the many obstacles in the way of uniformity remain much what they have always been. Imperfection in the charging also contributes to the occurrence of slips and hanging troubles, these being among the bug-bears which blast furnacemen fear and have to contend with. The state of the weather also comes into play by acting upon some kinds of ore. Variations in the blast also occasion fluctuations in the melting speeds, producing metal of varying carbon content. Notwithstanding these facts and difficulties the blast furnace, according to Mr. Fletcher, remains the cheapest form of ore-melting apparatus, but on the other hand it is found, when critically examined, to be of low efficiency as far as the quality of the product is concerned. An alternative would be the Basset process recently heard of on the Continent, by which, it is claimed in circles which appear to be well-informed, iron, cast-iron and steel can be produced direct from the ore; this, however, is only now being tried on a practical scale and, like Mr. Fletcher, we must wait for this new process to give actual proof of its economical advantages, if any, for it has many direct as well as side issues to contend against.

We have referred above to blast-furnace gas utilisation. We should like to be absolutely certain in our own mind that the saving made under this head is wholly a net saving—to know for a fact whether, when blast-furnace owners started utilising the blast-furnace gas under boilers or in gas engines, their coke consumption per ton of pig-iron showed no increase over the previous consumption.

The working of the cupola, "the smaller, smelting blast furnace," is also referred to by Mr. Fletcher. The analyses he gives of cupola waste gas and of blast furnace top gas are of interest; the figures quoted are the following, those for the blast furnace being in brackets: Carbon monoxide, 17 per cent. (7 per cent.); carbon dioxide, 10 per cent. (30 per cent.); hydrogen and hydrocarbons, 2 per cent. (4 per cent.); nitrogen, 71 per cent. (58 per cent.). In the cupola there is also lack of uniformity in the product, cast-iron. In comparing both forms of apparatus, the author finds that in the blast furnace, half the useful heat in the coke escapes with the head gases to the stoves; similarly, the cupola uses, in melting, slagging and radiation losses, about half the useful heat units in the coke, half being lost in the waste gases which, unlike those from the blast furnace, escape unutilised. The author disapproves, and very naturally so, the "slap-dash" method of charging the cupola by throwing pigs endwise and sideways on to the coke layer, and he deprecates also the scant attention which the fluxing of the sand and oxide covering the pig-iron and of the coke ash have received hitherto. He also calls attention to other points, such as the condition of the slag, the regulation of the blast, in relation to the good working of the cupola. The fact, therefore, remains that both the blast furnace and the cupola are to this day in effect what they have always been, namely, comparatively imperfect apparatus, but still the best available, while the working of both—the working of the cupola probably to a greater extent than that of the blast furnace—can be improved by greater care. That the working of the cupola can be controlled with a view to improving greatly the quality of the cast-iron, was brought out by Mr. H. J. Young, in a paper he read in December last before the Institute of Marine Engineers, as we reported at the time.

THE DISINTEGRATION AND EVOLUTION OF ELEMENTS.

To ordinary beings, decay precedes growth, devolution comes before evolution; the one phenomenon implies the other. Man can not create. He can give new forms to what existed in other forms. The chemist can synthetise, after having analysed. To build up a new element, he would have to break up old ones. As long as each element consisted of immutable atoms of its own, different from the atoms of any other elements, there could be no science of the genesis of the elements. There hardly is now. When discoursing, on April 8, at the Royal Institution, on the "Evolution of the Elements," Sir Ernest Rutherford had naturally more to say upon the startling disintegrations of atoms, not only of the radioactive elements, to the oddities of which people have gradually become accustomed, but even of elements of unquestioned steadiness such as nitrogen, than upon evolution. In fact, the hour allowed the lecturer had almost passed by the time that he came to the announced subject. But he wished to outline the considerations which had led him to the views he finally suggested.

When John Dalton, more than a hundred years ago (1808), had put the atomic theory, ancient in its conception, on an experimental basis, chemists were, as Sir Ernest remarked in his introduction, for many decades chiefly engaged in the search for, and examination of, new elements. But the more philosophically-inclined workers did not believe that all the 80 or more elements then known really represented as many different original materials. Already in 1815, Prout, again following up ancient ideas, advanced the hypothesis that the different atomic weights were all multiples of the atomic weight of the one primary substance of unit atomic weight, namely, hydrogen. All the atomic weights,

therefore, should be integers. The atomic weights were not accurately known at that time, however, and the subsequent redeterminations only shook the belief in Prout's integers and hypothesis. On the other hand, the periodic recurrence of the properties of the elements, when arranged in the periodic tables of atomic weights of Newlands, Mendeleieff and Lothar Meyer, were difficult to explain without some common constituent. Speculations as to the evolution of the elements remained fruitless, however, because nothing was known as to the structure of the atom, though many thinkers credited it with a structure. The late Norman Lockyer suggested that we were witnessing the evolution of elements in the stars, in which hydrogen, helium, iron, &c., seemed to appear at different stages. Lockyer, Sir Ernest said, probably was right in the main. But it was not until the discovery of the electron that real progress was made, and we owed a great deal to Sir J. J Thomson in that respect.

The essentially-electric structure of the atom and the nuclear theory were now considered assured, though they presented fundamental difficulties. All the mass of the atom was practically concentrated in the nucleus, which yet occupied not more than 1/5,000 of the dimensions of the whole atom. Pointing to a sphere of less than 6 in. diameter in front of him, Sir Ernest said the first ring of electrons surrounding that nucleus might be a couple of yards distant, and the outermost ring might extend to somewhere in Piccadilly. The positive charge of the nucleus was balanced, in the neutral atom, by the sum of the negative charges of the electrons of which there were 92 in the case of uranium. The electrons were all in rapid motion, all influencing one another, and the structure was very loose and open; yet the whole atomic system was controlled by the nucleus.

That the electrons were connected with the nucleus and that the structure was after all extraordinarily simple, we know from the work on X-ray spectra and on scattering. The fundamental thing was the nucleus charge. All the atoms were of the same kind; they differed as to the amount of that charge; hydrogen had charge 1, helium 2, lithium 3, &c., up to uranium with 92 charges. When we arranged the atoms in the order of these charges, which indicated also the number of electrons and the atomic or ordinal number N, we found a few gaps at N =43, 61, 75, 85 and 87; if any experimenter should come across one of these missing elements, he would be able to identify it by its X-ray spectrum. The study of the complex distribution of the electrons in the nucleus was occupying many investigators, and those studies had been most fruitful. But Sir Ernest wished to concentrate his attention upon the nucleus, which was a world in itself, about which very little was known.

The first point to be borne in mind was that as we approached an atom from outside, the old law of force, the inverse-square law, held until we came up to the innermost ring of electrons. Beyond that, Sir Ernest stated, the law must change; for otherwise the atom could not hold together. The forces at work were of a repulsive character, and the nucleus appeared to be surrounded by a region of impenetrability. To illustrate this, Sir Ernest had placed a large vertical solenoid on the table, and had suspended two smaller solenoids in pendulum fashion from the ceiling; the three brass balls of the solenoids represented all three similar poles. When a pendulum was pulled out and allowed to swing back, it would not hit the big pole (or rather, pass closely over it), but it would swing round in a curve, except when the pendulum speed was very high. Similarly an α particle shot against a foil of a heavy metal (gold) would not penetrate into it but would be sent back, or be deflected in a curve, coming straight back, when the centre of gravity of the two atoms (the projectile and the atom aimed at) were in a line with the direction of approach, and being deflected at various angles for what would be glancing collision (see Fig. 1). But when the α particle was discharged into a light gas like hydrogen, there might occasionally be actual collision between an α particle and a hydrogen molecule. In that case, the projectile, the α particle (a helium atom), was larger than the target; we might hence imagine the relations to be reversed, and say that the hydrogen would penetrate into the helium. The quite recent experiments of Chadwick and Bieler tended to show that the square law did break down in that case, and that the α particle was itself complex and behaved like a spheroid the two axes of which had the lengths 8 and 5×10^{-13} cm. Outside this spheroidal surface the inverse-square law applied; but the forces increased so rapidly that when the hydrogen nucleus entered the spheroid, it was rapidly turned back.

In order to prove that it was the nuclear charge, and not the atomic weight, which decided the properties of an element, Sir Ernest then referred to the radio-active disintegration in which the simple discharge of a particle (α or β) entirely changed the nature of an element, and which led to several

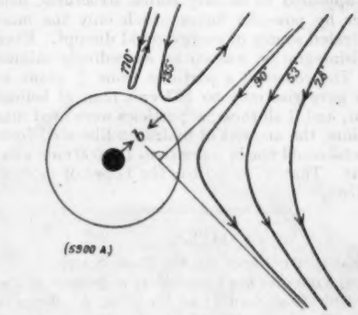


FIG. 1.

Fig. 2.

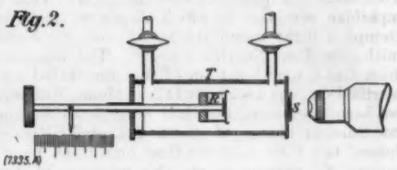


Fig. 3.

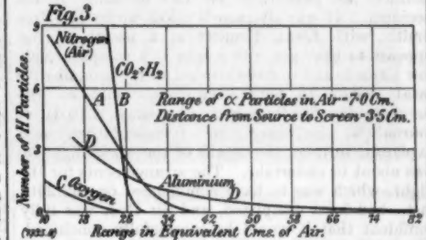
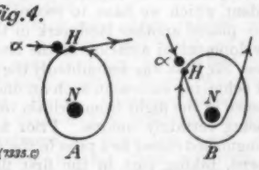


Fig. 4.



isotopes, bodies alike in all properties, apart from radio-activity, and yet of different atomic weights.* Radium had three such isotopes, thorium five, lead seven, and there were reasons to believe that isotopes were common all through the series of elements. But some elements, such as carbon oxygen, nitrogen, fluorine, were apparently single and had no isotopes. The search for isotopes was conducted by positive-ray analysis, and Aston had found that the atomic masses (or weights) thus determined were all very nearly whole numbers, taking oxygen = 16. On closer examination those numbers were found not to be really integers, however, and they could not be, Sir Ernest added, if helium nuclei made up part of the mass of the nucleus as he hoped to show. Yet the integer rule held approximately, and that indicated that the atoms were collections of a substance of mass 1.

Since, now, the α and β particles expelled by radium both came from the nucleus, the nucleus of those substances must in part at least be made up of helium nuclei and electrons. But radio-active disintegration never yielded any trace of hydrogen. In order to probe the structure of the atoms and perhaps to disintegrate the atoms, Sir Ernest, together with Dr. Chadwick, had bombarded various other atoms, with the swiftest and most powerful projectiles available, the α particles of Radium C which, travelling at speeds 10,000 times the speed of rifle bullet, carried 400,000,000 times their energy, mass for mass. The latest form of apparatus they used (Fig. 2) consisted of a brass tube T, 3 cm. in diameter, provided with a small hole at the one end, covered by a window of thin silver. In front of the window was the zinc sulphide screen S, the scintillations of which were observed and counted by the aid of a microscope so perfected that a field of 40 sq. mm. could be examined. Absorbing screens of mica were placed in the slit, only 1·3 mm. wide, between the window and S. The radio-active source R was fitted on the end of a sliding rod, the position of which could be varied. In order to keep out α rays which would complicate the phenomena, the whole apparatus was placed in a strong magnetic field, and the source R was directly covered with a thin foil or film or dust of the material to be studied, when the α particles were to be discharged into metals or compounds.

Let the tube T be charged with pure dry hydrogen. The chances that an α particle would actually collide with a hydrogen nucleus and disrupt it were extraordinarily remote, perhaps 1 in 1,000,000. But if it did, the hydrogen nucleus (or proton) hit, should, by the law of mechanics, be propelled in the direction of the α particle with 1·6 times the speed and 0·64 the energy of the latter. Striking the screen, if not too far away, the proton would cause a scintillation. Now, the numbers of such scintillations actually observed proved to be far in excess of the numbers to be expected if both the α particle and the proton were merely point charges: that suggested to Chadwick and Bieler the conclusion above-mentioned. Further, in the first experiments of this kind the tube was filled with nitrogen, air and carbon dioxide. Scintillations were then observed when the distance between R and S far exceeded the range of the α particles (7 cm. in air). In the case of oxygen, however, the scintillations were very scarce; as soon as the oxygen was replaced by nitrogen or by air, the number rose fourfold. The few scintillations in oxygen might have been due to the accidental presence of a little hydrogen. But why the great increase in the case of nitrogen? In all the cases, moreover, the particles causing the scintillations were, to judge by their magnetic deflection, really hydrogen nuclei. Again, most of the elements of low atomic weights so far tried gave such particles when bombarded by α particles. The ranges were different. They rose above 32 cm. in the materials boron, nitrogen (40 cm.), fluorine, sodium, phosphorus and aluminium (90 cm.) when referred to equivalent cms. in air. Fig. 3 illustrates some of the curves. Nuclei from hydrogen itself did not travel more than 28 cm. as in curve C, in which the material was oxygen, probably contaminated with hydrogen. Aluminium giving the greatest range of 90 cm. also showed another peculiarity. In most cases the hydrogen nuclei producing scintillation travelled on in the direction of the α particle; in the case of aluminium the collision effect was almost explosive, and nearly half of the nuclei seemed to be reflected back. That might be explained by Fig. 4. If it were one of the hydrogen-satellites of an aluminium nucleus that was struck, the α particle, that satellite would, as in the case, Fig. 4A, travel straight on; but in case shown in Fig. 4B it would describe a partial orbit, and almost appear to be reflected.

But as mentioned already, some elements did not seem to emit hydrogen nuclei when bombarded. Those were carbon, atomic weight $12 = 3 \times 4$, and pure oxygen, atomic weight $16 = 4 \times 4$, whilst boron $11 = 2 \times 4 + 3$, nitrogen $14 = 2 \times 4 + 2$, fluorine $19 = 4 \times 4 + 3$ did emit hydrogen. That is to say, elements of atomic weights $4n + \alpha$ gave hydrogen nuclei, whilst elements of atomic weight $4n$ did not. That, and other considerations suggested that the atoms of all elements consisted of helium

* Compare Sir E. Rutherford: Lectures on Radio-activity, page 387 *ante*.

nuclei of mass 4 and sometimes also of hydrogen nuclei. Now the helium nucleus itself was believed to consist of four hydrogen nuclei and two electrons. Thus the ultimate constituents of all the atoms would be hydrogen nuclei and electrons. Ordinary physical and chemical processes, light, electric discharges, &c., temporarily removed one or more outer planetary electrons which, returning, set up radiations; that did not affect the nucleus and the stability of the atom. To break up the atom we had to disrupt the nucleus, and that required the enormous energies of the bombardments spoken of.

Passing to the energy problem, Professor Rutherford pointed out that the mass of the helium atom, 4·00, was really a little smaller than that of 4 hydrogen atoms, $4 \times 1{\cdot}0077$ (oxygen being 16). The energy emitted in the formation of one gramme of helium from hydrogen corresponded to the loss of mass of 0·0077 gram.; on the modern views concerning the relations between mass and energy, the energy $= mc^2$ (where c is the velocity of light) was $0{\cdot}0077 \times 9 \times 10^{20}$ or 1·66 gram. calories or equivalent to the energy of 3·6 α particles from Ra C. That energy of the formation of helium from hydrogen might be the source of the stellar energy, and if we could by some means form helium from hydrogen, we should command energies which would be enormous even on the radio-active scale.

Sir Ernest then drew attention to some generalities recently dwelt upon by W. D. Harkins (Chicago). The most abundant elements found in the crust of the earth were oxygen, silicon and aluminium. Taking all the elements of somewhat wide occurrence, 85 per cent. of these were elements of even atomic numbers, and only about 13 per cent. were elements of odd numbers. Again nearly 99·9 per cent. of all the elements in the crust had atomic weights below 29, and the elements of higher atomic weights represented only 0·15 per cent. Those figures comprised meteorites, and there were similar peculiarities about the isotopes, peculiarities which any evolution theory would have to consider.

How, then, did we believe that elements had been evolved? We could hardly build up a new atom from an atom, say, of iron by forcing a further charge into it; for we knew that we would have to bring the α particle up very swiftly to be able to approach the heavy atom. That was hardly the way then, and the process was probably much more gradual and progressive, though all this was, of course, highly speculative. Suppose hydrogen was collecting somewhere in our system. The matter would contract gravitationally, according to Kelvin and Helmholtz, and evolve heat in doing so. At 1,000 deg. C. hydrogen would become ionised, and electrons would be lost; the nuclei would move about swiftly, the electrons still more freely. But even if the temperature rose to a million deg., the particles would only acquire speeds like those imparted to particles in electric discharge tubes by a potential gradient of 100 volts. The velocities of the particles expelled in radio-active disintegration were of the order of a million volts, and we should, therefore, require enormous temperatures.

But let us consider a hydrogen nucleus and its electron rotating about it. As a rule the electron would be far out. Under certain conditions, however, the orbit might be close, and the electron might jump into a temporary state of very high energy. The moment the positive and negative charges came close together, the structure would become fairly stable, and such neutrons or doublets might be able to arrange themselves in chains, little disturbed by the repulsive forces and by other nuclei, ultimately to unite in some way we did not understand. The atoms would condense in the course of millions of years giving out energy by losing electrons. These phenomena of growth and gradual condensation would be characterised by an enormous radio-activity. Helium was exceedingly stable, probably the most stable element known, and the one most liable to be formed under any conditions; its formation would liberate vast amounts of energy. The common atoms like oxygen and aluminium represented possible stable configurations, more readily formed than others. The elements of the uranium family were still shedding their surplus electrons, being in the last stage of their completion. We had to look to the stars for evidence of the evolution of the elements. We possessed in the elements of to-day the materials for our research, but we did not know the law of force in that world within the nucleus.

Sir Ernest Rutherford did not refer to the so-called transformations. He had done so a few weeks earlier when addressing the Chemical Society on artificial disintegration of the elements. He had then stated that the late Sir William Ramsay's production of neon and the liberation of lithium from copper had never been confirmed, nor had Collie's apparent transformation into helium of the electrodes of his discharge tubes. That helium had probably come from the metals; Winchester had found that the evolution of occluded hydrogen from aluminium electrodes continued until the electrodes were entirely dissipated. On the whole, then, atoms appeared to be very stable structures, held together by powerful forces which only the most concentrated source of energy could disrupt. Even then disintegration was on an exceedingly minute scale. The collected α particles from 1 gram. of radium gave rise only to 163 cub. mm. of helium per year, and if all these α particles were fired into aluminium, the amount of hydrogen liberated from that metal could not be more than 1/1,000 cub. mm. per year. That seems to bar the hopes of modern alchymists.

NOTES.

FATAL ACCIDENT TO SIR ROSS SMITH.

PROFOUND regret has been widely expressed at the death of Sir Ross Smith and Lieut. J. W. Bennett which occurred on Thursday, the 13th inst., at Brooklands as a result of an accident to the Vickers amphibian aeroplane in which they were about to attempt a flight round the world with Sir Keith Smith, Sir Ross Smith's brother. The machine, which was a modified form of that illustrated and described on page 486 of our 111th volume, had only just been completed, and had been flown for the first time in charge of Capt. Cockerell, Messrs. Vickers' test pilot, with Sir Ross Smith and Lieut. Bennett as passengers on the morning of the accident. It was afterwards taken up by Sir Ross Smith, with Lieut. Bennett as a passenger, but appears to have got into a spin at a comparatively low altitude and to have crashed to the ground with fatal results to both occupants. Only on the previous day Sir Ross had entertained a party of journalists, including our representative, and explained to them the details of the world flight he was about to undertake. The arrangements for the flight, which was to have commenced on the 25th inst., had been completed, and Sir Ross was fully confident that it would be successfully concluded. There is every reason to suppose that but for the fatal accident which we have to record, this flight would have placed another landmark in the history of the development of aviation to the credit of the British race. Sir Ross was undoubtedly the pilot most capable of achieving success in such an undertaking, his experience in the flight from Britain to Australia in 1919 being certainly unique. Prior to this, he had a distinguished career as a pilot in the Australian Flying Corps, taking part in the first flight from Cairo to Calcutta in December, 1918, and later in reconnaissance work in connection with aerodrome construction in Burma, Siam, the Malay States and the Dutch East Indies. Sir Ross was only 29 years of age, and his untimely end will be mourned not only in this country and in Australia, where he was born, but in all other countries where the value of his pioneer work in aviation can be appreciated.

THE GALICIAN PETROLEUM INDUSTRY.

If we consider the main ridge of the Carpathians roughly to be of horseshoe shape, the oilfields are all on the outer side of the horseshoe, and extend from Cracow down to Rumania and the Black Sea. In a long paper read before the Institution of Petroleum Technologists on April 11, Mr. Albert Millar stated that in Galicia the oil belt is about 400 km. long and 100 km. wide, containing 170 oilfields tapped at 420 places. The high-grade oil is of a paraffin base and contains 15 per cent. to 40 per cent. of benzine, and 20 per cent. to 35 per cent. of kerosene, the remainder being paraffin and lubricants. The best-known fields at Boryslaw-Tustanowice-Mraznica came in about 1900, at a time when the demand for oil was not great, and by 1908 oil prices had fallen and many small fields had to close down. Their turn came again when water troubles disastrously affected some of the big wells, the Tustanowice among them. The inrush of salt water was ascribed to the approaching exhaustion of the fields, water taking the place of oils, and to the diminution of the gas pressure which so far had kept the water in check. By 1915 the worst period of the trouble seemed to have passed; but it is still spreading, although the Austro-Hungarian Government did its best for the fields. The rubber which the submarine Deutschland brought back from America early in 1916 was manufactured into rubber rings for swabbing the wells. When the water in the oil emulsion brought up exceeds 30 per cent., wells are abandoned. When the water and dirt amount to less than 20 per cent. the emulsion is heated in closed tanks by steam coils for up to 12 hours, and allowed to settle; when the emulsion is poorer it is washed and heated with clean water, or better treated with caustic soda (5 kg. to 15 kg. per 10 tons of emulsion) and live steam. In the twenty years up to the end of 1921 the Boryslaw fields produced 17,600,000 metric tons of petroleum exclusive of fuel oil, &c. The production decreased before the war and was only 563,566 tons in 1921, the lowest figure since 1909, and about one-third of that best year. The production of natural gas has become very small; yet the gas is one of the principal assets, and there are two gas-pipe lines for the refineries. The largest of these refineries, the Palmin works at Drohobycz, are State property, and have a capacity of 300,000 tons; most of the other refineries (over 60) are small, and some of these have, since Galicia was assigned to Poland, passed into French possession. Transport difficulties have stood in the way of the development of some fields. The storage tanks, which near Boryslaw have a capacity of 1,430,000 tons, have suffered badly by the war, and the underground reservoirs called Ambars are mostly out of repair. The ozokerite production, which reached 10,400 tons in 1885, hardly exceeds 250 tons at present; the ozokerite was first found in lumps in the marl at low depth and dumped as valueless.

THE BUILDING TRADES EXHIBITION AT OLYMPIA.

(*Continued from page 464.*)

REINFORCEMENT of various kinds for use in connection with building work naturally forms an important item in the exhibition. We referred to some of the stands which are devoted to this class of material in our issue of last week, concerning ourselves mainly with reinforcements for concrete. There are, however, various forms of reinforcement on view intended for use with brickwork. As an example we would refer to the remarkably interesting display made by Messrs. B. Morton and Sons, of 78, Quay-street, Deansgate, Manchester. This firm shows examples of both reinforced concrete columns and walls built on their patented system. The columns are constructed with four or more vertical rods incorporated inside the brickwork and tied both to the foundation and to any overhead beam or other member which may be carried at the top. Every six to ten layers of bricks or so, depending on the load or other conditions, a perforated steel plate of the area and shape of the cross-section is introduced at a horizontal joint. The vertical rods pass through holes in the plates, and are tied together by them so that any bending moment is distributed over the rods. The steel plates, which are of stout gauge, also serve to distribute the load evenly over the brickwork.

This construction, with the bricks laid in cement, makes a remarkably solid job, and examples of heavy columns are to be seen at Olympia which have been shipped from Manchester ready built-up and as complete articles, the only modification in the normal construction being that the ends of the longitudinal ties have been screwed and plates secured with nuts to each end of the column. Probably the most remarkable tribute to

this form of construction lies, however, in the fact that it has actually been used for making brickwork piles. We understand that the construction of such piles is not one of the ordinary lines of business of Messrs. Morton, but such piles have been made and successfully driven. They were 14 in. by 14 in. and 40 ft. long, and were reinforced with four 1-in. longitudinal bars. Plates were inserted in every joint near the top which had to stand the driving blow. Lower down they were spaced further apart. The piles were successfully driven full length into heavy ground with a 40-cwt. tup falling 4 ft. The piles moved $\frac{3}{8}$ in. with the last five blows.

Messrs. Morton's reinforced brickwork walls are built with perforated steel strips in every sixth joint or so, and vertical rods placed a few feet apart are carried up in slots, or chases, formed on the faces of the wall. The chases are filled in with cement as the wall proceeds, and a good finish results. It will be clear that special bricks with side slots are required for both the column and wall construction, but the number of patterns is not large and the special bricks are inherently no more expensive than ordinary kinds, although being required in comparatively small quantities a higher price is no doubt charged for them. The advantages claimed for this method of construction over mass concrete is that the expense of shuttering is avoided and that the absence of shuttering eliminates delay in getting to work. A start may be made immediately the job is reached just as with ordinary brickwork. As compared with brickwork which is not reinforced the method saves both in material and weight, the latter consideration frequently considerably reducing the cost of foundations. A stable and entirely satisfactory wall can be built 3 in. thick with the bricks on edge. The construction has been much used for panel work in steel-framed factory buildings.

Another modern method of building, or rather modern form of building material, which is very fully represented at the exhibition is the asbestos-cement product in its various forms. Tiles, sheets and panels of this class are now manufactured by a number of firms and would appear to be coming very extensively into use. Many of them are well known, among which must be counted the "Poilite" tiles and sheets manufactured by Messrs. Bell's United Asbestos Company, Limited, of 59½, Southwark-street, S.E. This firm has an attractive stand in the form of a pavilion roofed and covered with their products. "Poilite" tiles in addition to the well-known diagonal form are now made corrugated under the name "Pantiles." This form gives a very pleasing effect when made up into a roof, and many will prefer it. Corrugated tiles are also shown by Messrs. Turner Brothers Asbestos Company, Limited, of Rochdale, the firm's stand being roofed with them to show the effect, which is excellent. Asbestos-cement sheets and other products of the firm are also shown. The stand of the British Everite and Asbestilite Works, Limited, of 29, Peter-street, Manchester, is in the form of a garage designed to show the uses of the firm's "Everite" corrugated sheeting, "Asbestilite" flat sheets and roofing tiles and slates. Material of the same class is shown by the British Roofing Company, Limited, of Premier House, 150, Southampton-row, W.C. 1. This firm's sheets and tiles are known under the name of "Alligator."

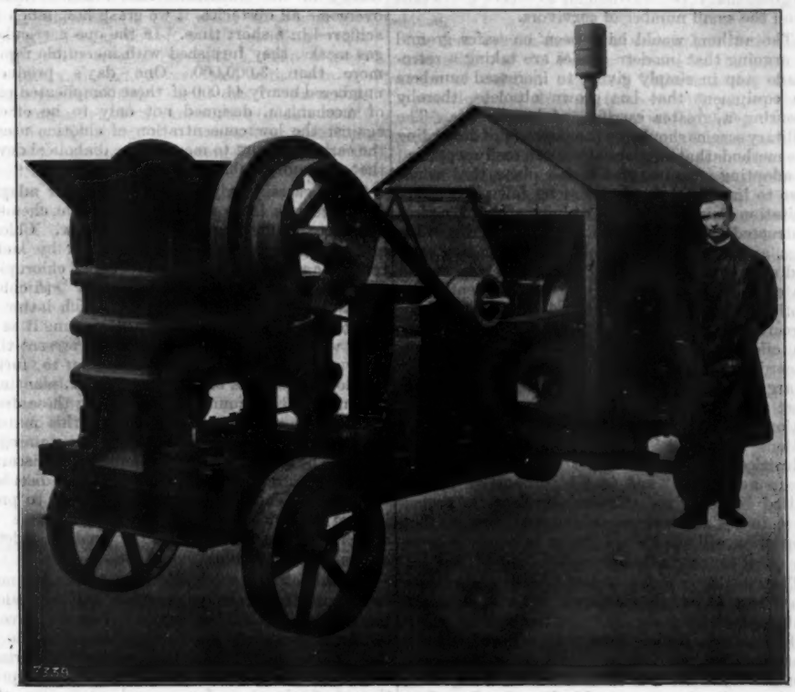


FIG. 5. OIL-ENGINE DRIVEN STONE BREAKER AND CRUSHER; MESSRS. WINGET, LTD., WARWICK.

Turning now to some of the exhibits which may be classed as machinery and which fall more nearly within our usual province, we may first refer to the excellent display made by Messrs. Winget, Limited, of Winget House, Grosvenor-gardens, S.W. 1. This firm's block-making machines are well-known, and we referred to them last week. They are, however, now turning their attention to more general labour-saving plant for builders and contractors, and have two portable conveyors and a portable elevator on view. These plants are in all cases self-contained with oil-engines and are fitted with road wheels. The elevator which is fitted with buckets is adapted for loading carts from a dump or from a sand or gravel pit. It will move from 20 tons to 30 tons of material an hour and has a maximum elevating height of 9 ft. The bucket chain is carried on a frame adjustable for regulating the distance of the charging point, while a lever control enables the direction of the machine to be altered while discharging, so that the vehicle which is being loaded can remain in one position throughout the operation. The engine is of 5 h.p.

The smaller of the two conveyors is driven by a 2 h.p. Aster engine and has a boom 19 ft. 6 in. long. The belt is fitted with seats so that the machine can load boxes, bricks, &c., into carts, as well as loose material. The larger machine is fitted with a rubber conveyor belt. It is built in sizes up to 49 ft. long with a 28 in. belt and a maximum delivery height of 18 ft. Such a machine can deal with from 40 to 70 tons of material an hour. The engine is fixed at a point near the centre of the boom so that the machine is balanced for road travel when the boom is lying horizontal. The drive from the engine to the lower conveyor pulley is by belt. A centre tower carried from the main carriage on which the road wheels are fixed is fitted with a wire rope lifting arrangement to control the position of the boom. The road wheels may be swivelled to a position at right angles to the normal to allow the conveyor to swing round about its lower end. The machine can be used for moving sand or other material from a dump to the position in which it is used, or for building dumps, &c. Another useful machine shown by Messrs. Winget takes the form of a stone breaker and crusher fitted with an engine and mounted on a chassis so that the whole forms a self-contained unit. The machine is illustrated in Fig. 5 annexed. The crusher is a jaw machine. The jaws, however, have a roller action, the top jaw moving forward while the bottom jaw is receding and *vice versâ*. This gives a good granulating action and at the same time prevents clogging and gives the equivalent of a forced feed. By changing an adjustable toggle plate different crushing movements may be given. The illustration is self-explanatory and requires little comment. As will be seen the crusher is belt-driven and is mounted on heavy wood blocks to reduce noise and eliminate some of the vibration.

Another excellent display of builders' machinery is made by Messrs. Builders and Contractors Plant, Limited, of 15, Victoria-street, S.W. 1. Among other plant this firm shows the "Exe" patent hoist which consists of an arrangement of rails which can be fixed to any scaffolding or similar structure and which enables loaded barrows or other material to be lifted to the working plane. The hoist platform comes down to ground level so that a barrow may be wheeled straight on to it. An oil-engine or electric-motor-driven winch forms part of the outfit and a simple hand lever control is fitted. A portable hoist crane is also shown. The tower of this is fitted on each side with an "Exe" hoist and a jib crane is carried at the top. The crane can be used to lift scaffold poles, steel reinforcement and other items which are too long to travel up on the hoist platforms. The crane can also carry chuting so that the plant can be used for pouring concrete. In this plant the vertical rails on which the hoists work do not, of course, require any fixing to scaffolding as they are carried permanently by the travelling tower. There is little doubt but that plant of the type of which these exhibits are examples might very profitably be used more extensively in building operations. They are in no way suited only to the largest class of building and would be very applicable to the majority of quite moderate sized work. As by far the largest item in present heavy building costs is still labour, anything that would tend to cut out hand carrying and the moving of materials manually should very quickly justify its employment.

Builders' machinery, but of a somewhat different class is also exhibited by Messrs. Stothert and Pitt, Limited, of Orchard Street, Westminster, S.W. 1. This firm shows a selection of their "Victoria" concrete mixers, and a combined stone drying plant and mixer for tar macadam. These examples of Messrs. Stothert and Pitt's work are well known and do not require description. Another machinery exhibit, but of quite a different class is made by Messrs. Sutcliffe, Speakman and Co., Limited, of Leigh, Lancashire, who show an example of their "Emperor" briquetting press. The machine is suitable for briquetting coal, ore, &c., or for making lime sand bricks. The latter duty is the one in which it is of place in a building exhibition. We gave a very fully illustrated description of one of Messrs. Sutcliffe, Speakman's briquetting presses in our issue of November 18 last, and need not re-describe it now. The firm also shows a pottery moulding machine. This is not a press in the straightforward sense since as the mould is closing the clay is spun and spread to conform to the mould shape. The result is an excellent quality of ware.

Another type of exhibit which may be classed as

machinery and to which we may make reference before concluding our article this week is the electric lift. As is usual at exhibitions of this kind the leading lift builders have arranged attractive displays. Messrs. Waygood-Otis, Limited, of 54 and 55, Fetter-lane, E.C. 4, Messrs. Marryat and Scott, Limited, of 28, Hatton Garden, E.C. 1, and Messrs. Medway's Safety Lift Company Limited, of 1 and 2, Bucklersbury, E.C. 4, each make good displays. The products of the whole of these firms are well-known and require no detailed comment. It is indeed not possible to deal with machinery of this class in a technical way without detail drawing and diagrams and much description which cannot well form part of a general exhibition notice. Further exhibits we will deal with next week, but before closing this section should say that a public lecture will be given at the exhibition on the 24th inst., by Professor Patrick Abercrombie, on "What we Mean by Town Planning"; on the 25th inst. by Mr. Halsey Ricardo, on "Permanent Colour Schemes in Building," and on the 26th inst. by Sir Lawrence Weaver on "Modern Domestic Architecture." In each case the lectures will be begun at 6 p.m.

(To be continued.)

LITERATURE.

Chemical Warfare. By Brigadier-General AMOS A. FRIES, U.S.A., and Major CLARENCE I. WEST, Reserve Corps, U.S.A. New York and London: McGraw-Hill Book Company, Inc. 1921. [Price 21s.]

MUCH has been written of late both in justification and in condemnation of the policy that urges the employment of chemical research in producing lethal gases for use in warfare. Those who condemn the practice urge that the horrors of war may be so enormously increased by the application of scientific knowledge, especially of chemistry, to devising new toxic weapons, that a return to barbarism is threatened. They view with apprehension the possibility that the employment of gases, introduced by the Germans in April, 1915 in defiance of the undertaking into which they had entered, should become a general and legitimate method of conducting military operations. It is true that the spectacle of cultivated nations trying to outvie each other in the production of asphyxiating gases, every new exercise of technical skill being more deadly than the last, is not edifying. It is repugnant and abhorrent to all the teachings of civilisation and the higher instincts of humanity. All this and much more may be confidently put forward, but those who urge the perfidy of the Germans and the cruelty of the practice must remember that much of their indignation is aroused by the fact that the English were the sufferers, being taken utterly unawares on that fatal day at Ypres, when the Canadians "saved the situation." Admiral Mahan, a more disinterested spectator, declared that it was illogical, and not demonstrably humane, to be tender about asphyxiating men with gas, when no objection is raised against blowing the bottom out of an ironclad at midnight and leaving the crew to perish miserably without a chance of rescue.

More in accord with Admiral Mahan and in opposition to the humanist section, the authors have written this book with the avowed purpose of creating a public opinion that will insist upon chemical preparation for offensive warfare. The first Director of the Chemical War Service in the United States Army, General Sibert, is almost brutal in his insistence on the necessity of exploiting chemical science. Men are nothing, he maintains, "in modern war unless they are equipped with the most effective devices for killing and maiming the enemy's soldiers, and thoroughly trained in the use of such implements." This is the thoroughly military view of one who sincerely and honestly demands that the troops should be furnished with the tools best adapted to work successfully, and, herein, he apparently represents the national view, for it will be remembered that the United States never signed the protocol of the Hague Conference, pledging the signatories not to use projectiles, whose only object was to distribute toxic gases. He occupies a stern, unflinching position, and one feels that the case is weakened by the special pleading, that urges that gas warfare, instead of being the horrible and ghastly curse depicted, is really the most humane and defensible act, when both combatants are prepared to use and to resist its effects. If war is carried on against savage and unprepared peoples, the use of gases can be made, say the authors, so humane that but very few casualties will result. In proof of their assertion, they quote medical records to show that of the Americans gassed, less than 2 per cent. died, and after nearly four years' experience, it is safe to say very few were permanently injured. But of casualties other than gas 25 per cent. died, while from 2 per cent. to 5 per cent. are maimed, blinded, or disfigured for life. The Americans were prepared for gas attacks, and therefore this last argument furnishes no criterion of what would happen in the case of savage and unprotected peoples. The result would probably resemble that which happened at Ypres, when the number of fatal casualties was so great that it became difficult to collect the details from the small number of survivors.

The authors would have been on safer ground in arguing that modern armies are taking a retrograde step in simply giving to increased numbers an equipment that has grown obsolete, thereby ensuring a greater sacrifice of human life. The military service should see the necessity of discarding the methods that inferior nations can easily copy, and of adopting measures on a higher plane, that would give to industrial development its full play, where imitation would be difficult or impossible. The less instructed enemy would be at a distinct disadvantage, and such a policy would tend to shorten wars and make victory certain. This policy may not be stated in so many words, but it is evidently the motive of the authors, who clearly and rightly perceive that chemical warfare has come to stay. An effective implement of war has never been discarded until it became obsolete. Therefore, it is argued that toxic gases is a lethal weapon that must not only be reckoned with by every civilised nation in the future, but is one which civilised nations should not hesitate to use. Developed industries for manufacturing these gases are therefore a necessity. "and just in proportion as the United States gives chemical warfare its proper place in its military establishment, just in that proportion will the United States be ready to meet any or all comers in the future."

The treatise is well calculated both to stimulate effort and to satisfy curiosity. The authors are dealing with new tactics and new methods, of which little is known, because secrets have been jealously guarded. But the United States authorities have broadened the avenues of information, recognising the increasing interest in this branch of warfare and failing to perceive any advantage in preserving silence about past history. The policy of maintaining undue secrecy is unhesitatingly condemned, as delaying progress and serving no useful purpose. The Germans knew far more about the manufacture and use of lethal gases than the Allies, and if they had been in possession of all we knew, it would not have increased their stock of information. It is said that in the form of gases, liquids and solids, they used no less than 18 poisonous compounds. We could retaliate with only about one-third of that number, and this alone shows the extent of their equipment and their ingenuity in employing it. The Americans coming into the field late in the day, added only one new compound to the choice catalogue the Germans had compiled. But this one, known as Lewisite, seems to be worthy of American skill and enterprise. General Fries describes it as the "Dew of Death," and with that title its deadly nature may be imagined. It is a vesicant, or blistering agent, and the arsenical penetrates the skin with direful effects. It also causes violent sneezing and is a powerful respiratory irritant. The compound was never used, but the authors hug themselves on the possession of an extremely valuable agent, and in this instance regret the premature publication of the chemical and pharmacological properties of this poison, whose discovery and preparation illustrate the possibilities of chemical research and indicate what may be expected in the next war.

The authors give a very interesting chapter on the early efforts of the American Expeditionary Force to get the necessary training in the use of gas, offensive and defensive, the difficulties in obtaining the necessary materials for gas manufacture, and the construction of efficient masks, dilating on the evils of inexperience and the want of preparation. The delay occasioned by want of practice and the inability to take the field immediately on landing have taught the Americans the necessity of prevision, and have determined the policy now pursued by the military authorities. In the future chemical warfare will form as much a part of the curriculum of officers' education as the theory of ballistics or aviation. There was, however, little reason for either disappointment or irritation, if it be remembered that a new and vital service had to be organised under war conditions, on a foreign soil, the home sources of men and materials 4,000 miles away, and all the difficulties of transport. We shall better understand the energy of the Americans that enabled them to overcome all obstacles, if we grasp how much they achieved in a short time. In the one particular of gas masks, they furnished with incredible rapidity more than 3,000,000. One day's production numbered nearly 44,000 of these complicated pieces of mechanism, designed not only to be efficient against the low concentration of chlorine used in the early days, but to meet all the diabolical devices that ingenuity subsequently introduced.

These gases, newly invented or rather adapted, for there was little with which organic chemistry was unacquainted, are passed in review. Chlorine and phosgene head the list, followed by lachrymators, among which must be reckoned chloropicrin and the abominable "mustard gas" [dichloroethylsulphide $(ClCH_2CH_2)_2S$], for which latter the authors entertain a special regard, viewing it as the most valuable war gas known at the present time. They look forward with confidence to further developments in its use, as for example, planting it in drums in the ground and exploding these drums as the enemy advances. To throw this material on the enemy, or of bursting shell containing it, seems to be regarded as an elementary and discarded practice. Arsenical derivatives are also discussed, but without enthusiasm, as they are apt to prove ineffective, while in some proposed forms the amount of arsenide required to produce a lethal concentration is prohibitive in use.

The history of the evolution of the gas mask and protective clothing for men and animals is treated at considerable length. Here we have to fall back upon individual protection as in the old days of armour. It speaks volumes for the alertness and capacity of our chemists, that taken by surprise, they devised means for general protection that proved adequate. Needless to say, we have gone far from those days in April, 1915, when handkerchiefs filled with moist earth, or rags soaked in a solution of washing soda were welcomed as effectual safeguards. To such primitive types followed the goggle eyepiece as a protection against lachrymators. The introduction of such gases as chloropicrin and superpalite by means of shell scattering, led to the use of more complicated forms as the "box respirator," requiring the use of absorbents in the shape of prepared charcoal and of granules of alkali permanganate. The apparatus was effectual but had obvious disadvantages arising mainly from a tight-fitting nose clip, an inconvenient mouthpiece and the lack of ventilation within the face-piece chamber. Numerous have been the improvements in detail, but the type remains, and inevitably causes a very great reduction in the military efficiency of the soldier, for reasons which physiologists can easily explain. But that is a drawback that has to be borne by both combatants alike, and those who view with horror the increasing use of toxic gas may hope that the cumbrous protective apparatus will become so complicated that it will bring about its own abolition, and the use of gases be abandoned.

Another form chemical warfare assumes is to produce smoke, clouds of dense smoke, which complicates every phase of fighting and can confer a great advantage on those who use the device intelligently. Its usefulness in cutting off the views of observers was first perceived on board ship, when by shutting off air from the furnaces, it was

easy to raise a cloud of black smoke by reason of the incomplete combustion of the coal. But in the Great War, smoke was used for deception, for concealment, for obscuring vision, for signalling, for disguising deadly gases and other purposes. Add to these many employments of smoke, the narrowly connected use of incendiary materials for bombs, grenades, flame-throwers, and other devices, and we may get some notion of the essential part the chemist is destined to play in the wars of the future. And yet there are those who regard him, or affect to regard him, as a mere civilian, a superfluity. But he will be to the general in the field what the engineer is to the captain on board ship. This contemptuous attitude towards science will bring its own punishment, for the successful commander of the future will be he who makes the best use of his material, whether brain or brawn. Before the war there was not an officer who knew that a white smoke was more effective than a black for screening purposes, or on what depended the maximum screening power, or the conditions that made for a low rate of dissipation. But a great many experiments and a vast fund of ready invention have produced the "smoke box," "the smoke candle" and other contrivances that quickly create a dense fog-like cloud, that hangs low, with high obscuring power, and which can, if necessary, be rendered absolutely innocuous. The world is still looking for more efficient smokes, and more efficient smoke producers. In the future smoke will be the defence of the infantry man against all forms of weapons, and it will be used on every field of battle, by every arm of the service and at all times, day or night. "And with smoke for protection will go its use along with poisonous gases. Every smoke cloud will be poisonous or non-poisonous at the will of the one producing the cloud, and this will be true whether it is produced from artillery shell, mortar bombs, hand grenades, smoke candles or other apparatus. Thus smoke and gas together will afford a field for the exercise of ingenuity greater than that of all other forms of warfare. The only limitation to the use of smoke and gas will be the lack of vision of commanders and the ignorance of armies."

The Electric Furnace. By J. N. PRING, M.B.E., D.Sc. London: Longmans, Green and Co. [Price 32*s.* net.]

As the author points out in the preface, the very high ranges of temperature attainable in the electric furnace has opened up a large field of usefulness not previously accessible, and the development in recent years, although stimulated by war conditions, has also been due to the inherent advantages of the application of electricity to industrial furnace work. Cleanliness, convenience and high efficiency are all factors which the industrialist strives to attain, and nowadays he is unwilling to sacrifice these qualities if they can be brought economically within the sphere of his achievement. These are qualities which belong to almost every application of electrical heating, so that although its general adoption appears to be hesitating and gradual, there can be little question that it will be in the near future very extensive.

Such a development will have a very important effect on the distribution of the world's centres of industry. The fortunate countries of the nineteenth century were those whose wealth was coal, while the fortunate countries of the twentieth century will be those who possess the wealth of water power. And although human ingenuity may retard, it cannot arrest this natural development.

Historically the electric furnace may be said to have begun with Davy in 1810, when he isolated the alkali metals and aluminium by means of his voltaic pile of 1,000 plates, and from this starting point the author traces the early attempts to apply electric heat and electrolysis to practical ends. It is noteworthy in reading this chapter to notice how much of this pioneer work was done in Britain. Wilde, Siemens, Cowles, were the scientific forerunners of the present industry, but the commercial development was carried out by the workers of other lands, and the names of Chaplet, Wöhler, Stassano and Heroult merely confirm that the countries to which the idea of electric heat appealed were those whose coal supplies were much less abundant than our own. The electric furnace operator should be a competent electrical engineer as well as a competent chemist or metallurgist, but the type of man to whom both subjects appeal is by no means common. Among the troubles from which electric furnaces have suffered this lack of suitable supervisors has not been the least, but it is one which eventually cures itself. But the many-sided attainments required are brought home by the variety of subjects dealt with in the next few chapters of this book. First of all the heating principles are stated, and then some types of furnaces required for laboratory work are described and illustrated very clearly. There follows a discussion of the principles of alternate-current working and their application to furnaces, while a brief chapter on transformers for furnace work details their requirements. The measurement of high temperatures, furnace refractories and heat losses are all treated briefly but with lucidity and balance.

The real subject-matter is approached with the consideration of the electric furnace in the manufacture of calcium carbide. Unfortunately, this chapter does not deal adequately with either the manufacture or the furnaces which have been found most suitable for the work. Diagrammatic sketches do not give any idea of furnace construction, which is the important part of their success, and compared with the later chapters on other branches of the subject this can only be considered a disappointing start.

In dealing with the synthesis of nitrogen products, however, the author is at his best. He knows his facts, and has evidently paid deep attention and study to the subject. The manufacture of nitrogen products from the atmosphere has already achieved a large success. Furnaces of the Birkeland-Eyde and Schönherr types in Norway were producing, in 1916, between 30,000 tons and 40,000 tons of pure nitric acid, together with 5,000 tons to 10,000 tons of nitrate of ammonia and 6,000 tons of nitrate of soda, and they were using a total power of nearly 110,000 kw. The yield of nitric acid from the high-tension arc processes, however, is only about 500 kg. per kilowatt-year, corresponding to a percentage of nitric oxide in the issuing gas of about 1¼. Such a figure shows the very low efficiency of working, since theoretically it should be possible by combining all the oxygen to get 22 per cent. of NO_2. There is still much room for improvement in the application of electricity to nitrogen recovery. Even so, however, synthetic nitrates are proving already a serious competitor to Chilian nitrates in European markets, and they have had their share in bringing about the present slump in this commodity. In 1918 it is estimated that the world's production of calcium cyanide was over 780,000 tons, practically none of which was produced in Britain, and the production of ammonium sulphate from the Oppau factory of the Badische Anilin Company alone was about 500,000 tons. One wonders if British people realise the meaning of these figures and the influence which they will have on the future cost of their living?

The electric smelting of iron ores is considered very fully, and details are given of the progress which has been made in Sweden and Italy, where they have been driven to adopt this method owing to the high cost of imported coal. It is stated that in 1920 pig-iron could be produced in electric furnaces in Sweden at about 20*s.* per ton less than its cost in their blast furnaces.

Corresponding with its importance there is more space devoted to steel furnaces than to any other section of the book, and although a great many of the furnaces described are only of historical importance, the information given is useful without being critical. It is obvious that the author has not had experience in the running of steel furnaces, as the descriptions are mostly of the type well known in the catalogues of the makers, but to those who only want general information the compilation will be found quite convenient and accurate. It is perhaps too much to expect that in a subject covering so wide a field one man can be found who is familiar with the practice in every branch and an expert in each.

Considering the book as a whole, Dr. Pring must be congratulated on the production of a very interesting monograph and a most useful record of electric furnace achievements in many fields. It is a valuable contribution to the literature of the subject, and by far the best book yet published on the electric furnace.

The Oil Encyclopædia. By MARCEL MITZAKIS. London: Chapman and Hall, Limited. 1922. [Price 21*s.* net.]

THIS work of reference has grown out of a series of articles contributed by the author to the *Petroleum World*, and which in their early stage earned the good opinion of the late Sir Boverton Redwood, who pronounced them to be "a valuable contribution to the literature of the subject." It goes without saying, that a reconstruction undertaken after years of experience and professional criticism have had their due effect, will exhibit many improvements on the original. A larger number of facts will be embraced, the information will be brought down to a later date, the convenience of the reader will be better consulted, and effete matter will tend to disappear. Indeed a book dealing with progressive changes as this does, needs frequent editions or yearly supplements, for the areas exploited increase, the changes and extensions in the conduct of the industry are many, and the mechanical appliances employed in the collection and distribution of the commodity assume new forms and acquire greater efficiency. When the number of such supplements, a clumsy expedient at best, becomes inconveniently large, entire revision or reconstruction becomes imperative. In this case, we have not had periodic additions, but the time has come when summarised information on many points is demanded, and the answers to specific questions made easily accessible. The war, with its aftermath of disorganisation in official bureaux and the consequent absence of authorized statistics, has both hindered the collection and delayed the publication of much valuable information, whose circulation would have proved of material advantage to the petrol community. By this work the ill effects of delay are to some extent remedied, though the encyclopædic form of arrangement adopted is incompatible with the presentation of a consecutive history, in which may be perceived the mutual influences, the connections and operations that have encouraged the rapid development of the industry.

The most obvious requirements needed to ensure the success of such a book have been fulfilled. The information is brought up to date, and made, within limits, complete and accurate in all essential respects with regard to each item considered. Some repetition must be allowed, if cross-references are not to be troublesome by their frequency, but this is a necessity from the form of the work. A close examination of the contents shows that care and diligence have been exercised in the selection of material, and a proper sense of perspective has apparently been preserved, but this could only be decided by knowing what has been rejected, probably a mass of matter not inferior to that retained.

Since the mechanical preparation of such a book requires a considerable time and official statistics are apt to be belated, it is eminently satisfactory to find much of the tabular work extends to the end of 1920. We could have wished that more of the statistical matter had been put in the form of graphs, with provision for extending the curves as later information became available. The absence of any diagram or illustration cannot but be regarded as a regrettable omission.

When statistics are not involved and the information is derivable from domestic sources, references are made to the history of 1921. The description of the policy pursued by England and France in regard to the petroleum fields of the Near East, and the attitude assumed by the United States towards that policy, furnishes an instance, and we have no reason to think such recent references exceptional. The experimental operations recently undertaken in Derbyshire and Staffordshire are sufficiently detailed for a work of this character, and the conditions of the borings so late as September, 1921, are fully described, though the history of many of these necessarily stops at the date of their abandonment. It is more difficult to trace the present position and prospects of the shale industry, but a failure to hit

upon the correct "key" word may explain the disappointment. Unfortunately the work is not supplied with an ample index.

Some of the geographical references could easily have been dispensed with. Apparently it was the compiler's intention to insert the name of every district where petroleum has been worked or has offered prospects for working, but the information given is not in proportion to the space occupied. To be told, for example, that "Ragusa (Sicily) contains traces of oil," or "Kirta is a petroliferous district of Baluchistan," does not materially increase our knowledge when nothing more is added and no further use is made of the fact. The form of the work is, however, seen to be most inadequate and the greatest disappointment will probably be felt, when an attempt is made to describe within a few paragraphs the main processes of the industry that have been elaborated by skill and experiment, and perfected by the ingenuity of many brains. Such operations as distilling and cracking may be instanced. This is not the author's fault, except he is to be blamed for undertaking an impossible task, for anyone who has made a study of the methods and machinery employed knows that the whole interest is centred in the details. On the other hand, the financier or investor will find useful and accurate information. Does he want to know the history of the Standard Oil Company or to trace the influence and ramifications of the Shell Transport Company, he will most probably find the details needed.

BOOKS RECEIVED.

Electrical Engineering Testing. A Practical Work on Continuous and Alternating Currents, for Second and Third Year Students and Engineers. By G. D. ASPINALL PARR, M.Sc., M.I.E.E., A.C.G.I. Fourth edition, revised and enlarged. London: Chapman and Hall, Limited. [Price 16s. net.]

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. Vol. I, HO; Vol. II, F, Cl, Br, I, Li, Na, K, Rb, Cs. By J. W. MELLOR, D.Sc. London: Longmans, Green and Co. [Price 3l. 3s. net each volume.]

Department of Scientific and Industrial Research. Fuel Research Board. Special Report No. 1. *Pulverised Coal Systems in America.* By LEONARD C. HARVEY. Revised edition. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 5s. net; post free 5s. 3½d.]

The Practical Engineer Mechanical Pocket Book and Diary, 1922. London: Technical Publishing Company, Limited. [Price 2s. 6d. net.]

Manuale per il Collaudo delle Macchine Elettriche. Per Ing. G. BIANCHI. Milano: Ulrico Hoepli. [Price 18·50 lira.]

Mechanical Testing. Vol. I. *Testing Materials of Construction.* By R. G. BATSON, M.Inst.C.E., M.I.Mech.E., and J. H. HYDE, A.M.Inst.C.E., M.I.A.E., A.M.I.Mech.E. London: Chapman and Hall, Limited. [Price 21s. net.]

Manufacture of Portland Cement. By ARTHUR C. DAVIS, M.Inst.C.E., M.I.Mech.E., F.C.S. Third edition, revised and enlarged. Dublin; John Falconer. [Price 25s.]

An Introduction to the Study of Metallography and Macrography. By LÉON GUILLET and ALBERT PORTEVIN. Translated by LEONARD TAVERNER, A.R.S.M., D.I.C. London: D. Bell and Sons, Limited. [Price 30s. net.]

The Practical Engineer Electrical Pocket Book and Diary, 1922. London: Technical Publishing Company, Limited. [Price 2s. 6d. net.]

Commercial Contracts. An Exposition of the Law for Business Men. By E. J. FARRY, B.Sc., F.I.C., F.C.S. London: Sir Isaac Pitman and Sons, Limited. [Price 5s. net.]

Elements of Fractional Distillation. By CLARK SHOVE ROBINSON. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 12s. 6d. net.]

Construction Cost Keeping and Management. A Treatise for Engineers, Contractors and Superintendents engaged in the Management of Engineering Construction. By HALBERT POWERS GILLETTE and RICHARD T. DANA. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 25s. net.]

Protective Relays. Their Theory, Design and Practical Operation. By VICTOR H. TODD. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 12s. 6d. each.]

The Airplane Engine. By LIONEL S. MARKS, B.Sc., M.I.Mech.E. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 30s. net.]

Metallurgy of Zinc and Cadmium. By H. O. HOFMAN, E.M., Met.E., Ph.D. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 20s. net.]

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Government of Japan. Department of Railways. Annual Report for the Year Ending March 31, 1919. Tokio: Department of Railways.

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Ministry of Munitions and Department of Scientific and Industrial Research. Technical Records of Explosives Supply, 1915–18. No. 5. Manufacture of Sulphuric Acid by Contact Process. London: Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 2s., post free.]

Elektrische Messtechnik. Theorie und Praxis der Elektrischen und Magnetischen Messungen. Von WILHELM JAEGER. Second edition, enlarged. Leipzig: Johann A. Barth. [Price 138 marks.]

Les Relations Économiques entre la Grande-Bretagne et la Suisse dans le Passé et le Présent. Par WILLIAM WALDVOGEL. Neuveville: W. Henry.

Association of Engineering and Shipbuilding Draughtsmen. Electrically-Driven Colliery Winding Engines. By H. MARSHALL. London: Offices of the Association, 96, St. George's-square, S.W. 1. [Price 1s. net.]

Turbines à Vapeur. Par M. POINCET. Paris: J. B. Baillière et fils. [Price 35 francs.]

La Renaissance des Établissements Caïl. Par RENÉ THÉRY. Paris: Société Française de Constructions Mécaniques.

Notes and Examples on the Theory of Heat and Heat Engines. By JOHN CASE, M.A. Second edition, revised and enlarged. Cambridge: W. Heffer and Sons, Limited. [Price 7s. 6d. net.]

Hydro-Electric Survey of India. Vol. III. *Triennial Report with a Preliminary Forecast of the Water Power Resources of India, 1919 to 1921.* By J. W. MEARES, C.I.E., F.R.A.S., M.Inst.C.E., M.Am.I.E.E. Calcutta: Superintendent, Government Printing. [Price 4 rupees.]

Reinforced Concrete Simply Explained. By OSCAR FABER, O.B.E., D.Sc., Assoc.M.Inst.C.E., A.C.G.I. London: Henry Frowde and Hodder and Stoughton. [Price 5s. net.]

Monographs on Mineral Resources with Special Reference to the British Empire. Potash. By SYDNEY J. JOHNSTONE, B.Sc., A.I.C. New edition, revised and enlarged. London: John Murray. [Price 6s. net.]

United States Geological Survey. Mineral Resources of the United States, 1917. Part I. *Metals.* H. D. MCCASKEY, Geologist-in-Charge. I: 8. *Antimony in 1920.* By FRANK C. SCHRADER. I: 10. *Secondary Metals in 1920.* By J. P. Dunlop. I: 11. *Silver, Copper, Lead and Zinc in the Central States in 1920. Mines Report.* By J. P. DUNLOP and F. BEGHMAN. I: 12. *Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1920. Mines Report.* By C. W. HENDERSON. I: 23. *Iron Ore, Pig-Iron and Steel in 1919.* By ERNEST F. BURCHARD. I: 24. *Zinc in 1919.* By C. E. SIEBENTHAL and A. STOLL. I: 25. *Gold and Silver in 1919 (General Report).* By J. P. DUNLOP. I: 26. *Cobalt, Molybdenum, Nickel, Tantalum, Titanium, Tungsten, Radium, Uranium and Vanadium in 1919.* By FRANK H. HESS. I: 27. *Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1919. Mines Report.* By CHARLES W. HENDERSON. Washington: Government Printing Office.

United States Bureau of Labour Statistics. Bulletin No. 286. *Union Scale of Wages and Hours of Labour, May 15, 1920. No. 288. Wages and Hours of Labour in Cotton-Goods Manufacturing, 1920.* Washington: Government Printing Office. [Price 10 cents.]

United States Bureau of Mines, Miners' Safety and Health Almanac, 1922. Compiled by R. C. WILLIAMS. [Price 5 cents.] Bulletin No. 186. *Investigations of Zirconium, with Special Reference to the Metal and Oxide. Historical Review and Bibliography.* By J. W. MARDEN and M. N. RICH. [Price 25 cents.] No. 187. *Treatment of the Tungsten Ores of Boulder County, Colo.* By J. P. BONARDI and J. C. WILLIAMS. [Price 25 cents.] Technical Paper No. 249. *The Determination of Oxides of Nitrogen.* By V. C. ALLISON and others. [Price 5 cents.] No. 291. *Production of Explosives in the United States during the Calendar Year 1920. With Notes on Mine Accidents due to Explosives.* By WILLIAM W. ADAMS. [Price 5 cents.] Washington: Government Printing Office.

United States Geological Survey. Bulletin No. 725—F. *Pyrite at the Haile Mine, Kershaw, South Carolina. With a Note on Pyritization at the Brewer Mine, near Jefferson.* By FRANK C. SCHRADER. Washington: Government Printing Office.

L'Éther Actuel et ses Précurseurs (Simple Récit). Par E. M. LEMERAY. Paris: Gauthier-Villars et Cie.

Motor Cycle Efficiency and How to Obtain It. Simple Timing Hints for Motor Cyclists. London: Temple Press, Limited. [Price 2s. 6d. net.]

THE INSTITUTION OF CIVIL ENGINEERS.—The Council of this Institution have made the following awards for papers read and discussed during the session 1921–22:—Telford medals to Sir Henry Fowler, K.B.E. (Derby), Mr. H. N. Gresley, C.B.E. (Doncaster), and Mr. H. F. Parshall, D.Sc. (London); a Watt medal to Mr. William Willox, M.A. (London); an Indian premium to Mr. F. G. Royal-Dawson (London); Telford premiums to Mr. A. W. Rendell (Bournemouth), Mr. W. F. Stanton, B.Sc. (Chile), and Mr. A. C. Walsh (Chile). The awards for papers printed without discussion in the Proceedings for this session will be announced in the autumn. The council have also made the following awards for papers printed without discussion in the Proceedings for the session 1920–21: A George Stephenson medal to Mr. J. H. Taylor (Buenos Aires); Telford premiums to Mr. F. H. Hummel, M.Sc. (Belfast), Mr. E. J. Finnan, M.Sc. (Belfast), and Mr. Herbert Chatley, D.Sc. (China); and a Trevithick premium to Mr. G. E. Lillie, F.C.H. (Reigate).

THE LATE DR. ISOJI ISHIGURO.

WE regret to have to record the death, which occurred in Japan, on January 14, of Dr. Isoji Ishiguro, who was an associate member of the Institution of Civil Engineers since January, 1882, and a full member since April, 1900. He was the second son of the late Mr. Chihiro Ishiguro (who was one of the Samurai in feudal times), and was born on June 10, 1855.

Dr. Ishiguro was educated at Tokio University, where he graduated in July, 1878, and obtained the degree of M.Sc. He then came to this country and served a three-years' apprenticeship, from 1879 to 1882, with Mr. Edward Easton, Delahay-street, Westminster, with whom he remained afterwards, as assistant engineer, until 1884. He was made D.Sc. of Tokio University in August, 1891. On his return to Japan Dr. Ishiguro served the Japanese Government down to the year 1906. He acted as ordinary engineer and afterwards as chief engineer to the Home Department of the Imperial Japanese Government from 1885 to 1898. Also, from 1886 to 1890, and again from 1898 to 1906, Dr. Ishiguro was chief engineer of civil engineering works and inspector-general of the Works Department of the Imperial Japanese Navy. He, further, acted as lecturer in sanitary engineering at the Tokio University from January, 1885, to June, 1886. During his period of service with the Japanese Government, Dr. Ishiguro designed and carried out various drainage systems, the improvement of several rivers, civil engineering work for naval stations, harbour works, the schemes for raising a number of sunken Russian men of war, &c. On his retirement from Government service, at the end of 1906, he was appointed chief engineer to the Uji River Hydro-Electric Power Company, Limited, and designed and carried into execution the scheme for generating 50,000 h.p. in connection with Lake Biwa.

Mr. Ishiguro was on the council of the Imperial Japanese Steel Works, a member of the committee of the Tokio City Improvement, a member of the Imperial Japanese Seismological Society, of the Japanese Government Railway Construction Board, &c. He was a member of the House of Peers, having been appointed by H.M. the Emperor of Japan in December, 1907; he also held an honorary position at the Imperial Court Attendance since July 1908, and was a full member of the Engineering Society of Japan (Tokio).

PERSONAL.—The Bristol Aeroplane Company, Limited, have concluded arrangements for granting the sole licence to manufacture the 400-h.p. Bristol "Jupiter" radial air-cooled aero engine in France to the well-known Gnome and Le Rhône Engine Company.

THE MINING INSTITUTE OF SCOTLAND.—The forty-fourth annual report of this Institute, now issued, gives the total number of members as 693, a net increase of 10 compared with the preceding year. In addition there are 20 subscribing firms. During the year a student section has been successfully inaugurated and has attained a membership of 51, of whom 23 are junior students.

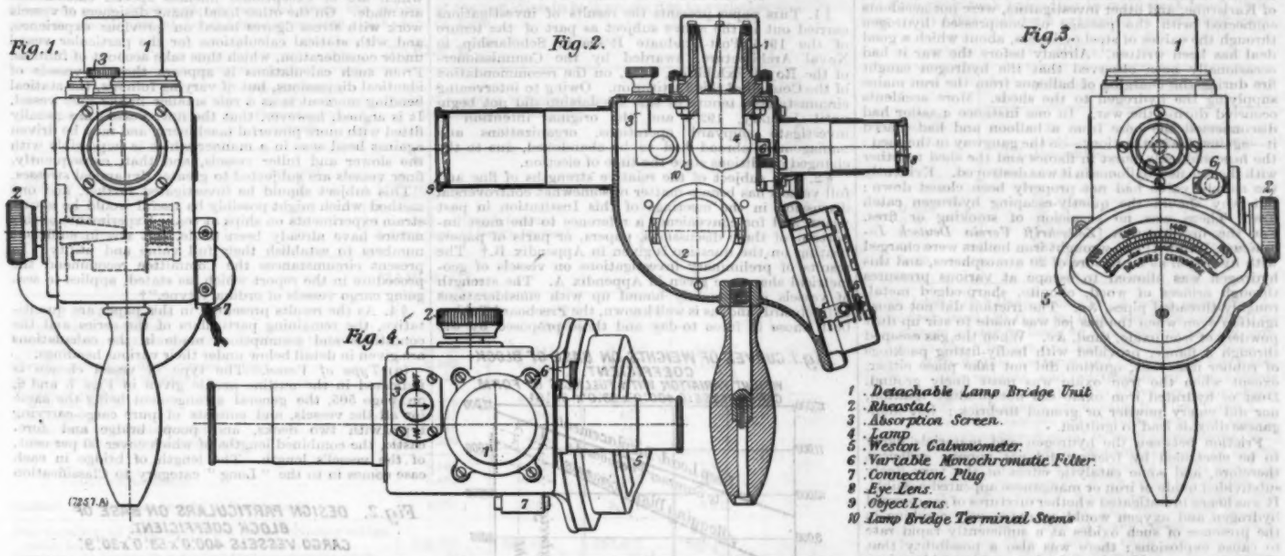
BRITISH IRON AND STEEL PRODUCTION.—The production of pig-iron in March amounted to 389,800 tons, compared with 300,100 tons in February and 386,000 tons in March, 1921. Furnaces in blast at the end of March numbered 107, compared with 109 before the coal stoppage and 101 at the end of February, 1922. Of the production of pig-iron in March, 149,300 tons were hematite, 113,000 tons basic, 86,000 tons foundry and 20,100 tons forge. The production of steel ingots and castings amounted to 549,400 tons, a figure higher than in any previous month since December, 1920, when it was 746,600 tons.

RAPID SHIP-REPAIR WORK.—One of the large Grängesberg boats, engaged in the iron ore trade, went aground off the Norwegian coast, incurring serious damage to her bottom. She was docked in Gothenburg, and as she was sailing under the German flag, tenders for the repair work were also invited from Germany. The German and Swedish quotations were about the same, but whilst the German yards stipulated for 50 and 65 working days, respectively, a Gothenburg yard, which secured the contract, undertook to do the work in 42 working days. Working with three shifts, the repairs were actually finished in 36 days instead of 42.

WORK OF AMERICAN ENGINEERING STANDARDS COMMITTEE.—The activities of the American Engineering Standards Committee have developed to such an extent, says *The Iron Age*, New York, that work is now under way on 79 distinct projects, such as industrial lighting, structural steel shapes, specifications for fire tests, a safety code for abrasive wheels, ball bearings, a safety code for compressed air machinery, a safety code for foundries, gears, a safety code for machine tools, a safety code for power presses and specifications covering non-ferrous and ferrous metals. In this work, 160 bodies of national importance are co-operating, these having designated more than 500 individuals as official representatives to serve on sectional committees working under the auspices of the head committee.

DISAPPEARING FILAMENT PYROMETER.

CONSTRUCTED BY MESSRS. H. TINSLEY AND CO., SOUTH NORWOOD.



THE accompanying illustrations show the design and construction of a useful form of optical pyrometer for industrial and laboratory work made by Messrs. H. Tinsley and Co., Werndee Hall, South Norwood, S.E. 25. It is of the well-known disappearing-filament type, but includes some special features based on the work of Dr. E. Griffiths and Mr. F. H. Schofield, of the National Physical Laboratory. In pyrometers of this type, an object glass is employed to form an image of the hot body in the same plane as the filament of a small electric incandescent lamp, and both are viewed together through an eyepiece consisting of a lens and a piece of red glass. The current through the lamp filament is adjusted by means of a rheostat, so that the temperature of the filament is equal to that of the hot body and when this is the case, the filament becomes indistinguishable, its colour then being exactly the same as that of the background. Before this adjustment has been made, the filament is visible either as a dark line on a lighter background, or *vice versâ*. The lamp having been previously calibrated against a hot body at known temperatures, the value of the current passing through it can be used as a measure of the temperature of any other body.

The construction of the instrument made by Messrs. Tinsley is shown in Figs. 1 to 4, the essential parts being indicated by reference numbers to which a key is given; Fig. 5, which is reproduced from a photograph, gives a good idea of its general appearance. As will be gathered, the instrument is a very compact unit which contains the complete optical system, lamp, resistances, rheostat, &c., the only auxiliary required being a 4-volt accumulator for supplying the current. This accumulator is connected to the instrument by flexible leads shown in Fig. 5. In use, the instrument is held in one hand by the handle provided, and the furnace, or other hot body, is observed through the eyepiece while the rheostat is adjusted by the other hand. When the filament disappears, as explained above, the reading of the indicator, which is mounted just below the eyepiece, gives the temperature directly. For continuous use in one position it will be found convenient to mount the instrument on a stand, and the makers supply a suitable stand for this purpose having a recess for the accumulators in the base.

In disappearing-filament pyrometers as commonly constructed the temperature indicator is a sensitive milliammeter in series with the lamp and battery. This arrangement, however, has the important practical drawback that, since a very small variation in current produces a considerable change in the temperature of the filament, the scale of the milliammeter, when graduated to give a direct reading of temperature, is very compressed. To expand the scale to some extent, the expedient of setting back the zero has been adopted in some cases, but this has the disadvantages that the true zero of the instrument cannot then be checked and the spring of the indicator is in a permanent state of strain. The special feature of the instrument we are now considering is the method adopted for overcoming these difficulties.

For this purpose the lamp is placed in one arm of a Wheatstone bridge, the two ratio arms of which are

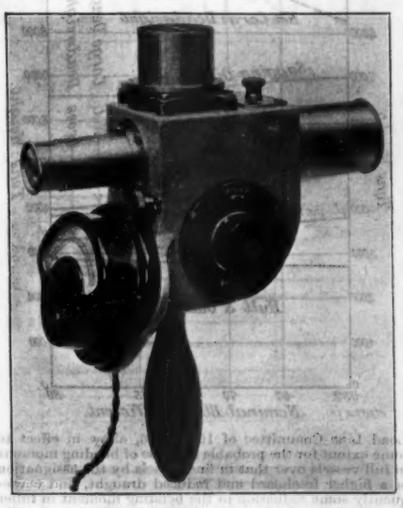


FIG. 5.

manganin resistances. The fourth arm also consists of a manganin resistance and the indicating instrument is a Weston galvanometer having a resistance in series with it to enable the sensitivity to be adjusted. The current supplied to the bridge by the accumulator can be regulated by a rheostat. It will be evident that if the resistance in the fourth arm is adjusted so as to balance the bridge for any particular value of the current through the lamp, the filament temperature corresponding to that current will be the zero on the scale of the galvanometer, since no current will flow through the latter when the bridge is balanced. If the current in the bridge is then increased the temperature of the lamp filament increases, as also does its resistance, and as the other resistances in the bridge arms are constant, the balance will be disturbed and a current will flow through the galvanometer, causing it to deflect. The resistance in series with the galvanometer is given such a value that the maximum deflection corresponds to the desired upper limit of temperature, and by this means the required temperature range is made exactly to fill the whole length of the scale. The instrument illustrated in Fig. 3, for example, would be balanced at 1,200 deg. C. and the upper temperature limit would be 1,510 deg. C.; the scale, it should be mentioned, is 3 in. long.

A moment's consideration will show that if the current flowing through the lamp is less than that corresponding to a temperature of 1,200 deg. C., the galvanometer needle would be deflected to the left, i.e., off the scale. This, however, is obviated and the instrument made suitable for measuring lower temperatures by the simple expedient of reversing the direction of the flow of current through the bridge by changing over the accumulator leads. This is equivalent, in effect, to doubling the length of the scale and, in the case of the instrument illustrated, of giving a total range from 700 deg. C. to 1,510 deg. C. In order to avoid possible confusion from this arrangement, the flexible leads from the accumulator are marked in the usual way (red for positive) and the polarity is changed by means of a reversing plug marked on each side to indicate the appropriate scale. The scale in use can also, of course, be ascertained by noticing in which direction the needle is deflected when the filament current is increased.

The various resistances which form the bridge arms, as well as that in series with the galvanometer, are wound on a tube which encases the holder of the lamp and forms, with the lamp itself, a single unit. The unit is attached to the body of the instrument by four screws, as shown in Figs. 2 and 4, and these screws also serve to make the necessary connections to the battery and galvanometer. If the lamp should be damaged, the complete "lamp-bridge unit," as it is called, can be replaced by another in a few minutes, since units designed for the same temperature range can be made interchangeable; otherwise it would be necessary to return the instrument to the makers for re-calibration.

In practice, the pyrometer may be relied upon to preserve its calibration for a very long period, provided that the maximum temperature of the filament of the lamp, which is carefully aged by the makers, does not exceed about 1,400 deg. or 1,500 deg. C.—preferably the former figure. This sets an upper limit to the primary scale of the instrument, but a secondary scale for higher temperatures can be provided by the insertion of a glass absorption screen between the object glass and the lamp filament; the fitting for this purpose is indicated by the reference number 3 in Figs. 1, 2 and 4. Two absorption screens can be supplied, and an idea of their effect may be gathered from the fact that a pyrometer having a primary scale ranging from 700 deg. to 1,300 deg. C. would have its range increased from 900 deg. to 2,000 deg. C. with one of these screens and from 1,000 deg. to 2,500 deg. C. with the other screen. Using the two screens together would give the instrument a range of from 1,300 deg. to 3,500 deg. C. Suitable scales can, of course, be provided so that the pyrometer can be used with or without the screen or with different screen combinations.

The instruments are calibrated by the makers against a standard thermo-couple heated in a platinum-wound, black-body furnace, the thermo-couple being checked periodically at the National Physical Laboratory. We understand that, in practice, the readings obtained are found to fall within limits of 5 deg. C., and that if the mean of a number of readings is taken the results of different observers will agree within 2 deg. or 3 deg. C. It should be mentioned, in conclusion, that a patent application covering the special design features described above has been lodged.

SPONTANEOUS IGNITION OF ESCAPING HYDROGEN.

THE cases of spontaneous ignition of hydrogen which recently occupied the attention of Professor W. Nusselt, of Karlsruhe, and other investigators, were not accidents connected with the passage of compressed hydrogen through the valves of steel cylinders, about which a good deal has been written. Already before the war it had occasionally been observed that the hydrogen caught fire during the charging of balloons from the iron mains supplying the hydrogen to the sheds. More accidents occurred during the war. In one instance a sailor had disconnected the hose from a balloon and had placed it—against his instructions—on the gangway in the shed; the hose suddenly burst in flames and the shed together with the two new balloons in it was destroyed. Evidently the supply valve had not properly been closed down; but why should the quietly-escaping hydrogen catch fire? There was no suspicion of smoking or fires. For the investigation [*Zeitschrift Verein Deutsch Ingenieurs*, March 4] two wrought iron boilers were charged with hydrogen at a pressure of 20 atmospheres, and this hydrogen was allowed to escape at various pressures through orifices of wood, ebonite, sharp-edged metal, roughly-threaded pipes, &c. The friction did not cause ignition even when the gas jet was made to stir up dust powders of iron oxide, sand, &c. When the gas escaped through a flange, provided with badly-fitting packings of rubber materials, ignition did not take place either, except when the iron oxide was most finely ground. Dust of hydrated iron oxide did not produce ignition, nor did emery powder or ground firebrick; but manganese dioxide lead to ignition.

Friction between the hydrogen and materials likely to be electrified by friction did not appear sufficient therefore, and some catalytic effect of the very finely subdivided oxide of iron or manganese appeared possible. It was hence investigated whether mixtures of compressed hydrogen and oxygen would spontaneously combine in the presence of such oxides at a sufficiently rapid rate to cause explosions; there was also a possibility that the hydrogen would reduce the iron oxide yielding iron in a finely-divided pyrophoric state ready to take fire on exposure to air. Mixtures of hydrogen and oxygen were placed in steel vessels containing some iron oxide; the gas pressure, measured by a gauge, was 10 atmospheres or less. At ordinary temperature the pressure gauge did not mark any noteworthy change for several weeks; at 100 deg. C. the pressure still remained constant for a day, after having first risen owing to the thermal expansion, but when the vessel was placed in an oil bath finally heated to 400 deg. C., the pressure fell, indicating combination of the two gases. At 200 deg. C. no oxygen was left after 9 hours, at 380 deg. C. the combustion was complete in 1 hour; but there was never any explosive combustion, even when the whole apparatus, electrically heated in this instance, was revolved so as to keep the powdered iron oxide in agitation. We should mention that the mixtures contained an excess of hydrogen.

Other experiments were then tried. The hydrogen was allowed to escape into a funnel narrowing into a gas pipe, 20 m. long, the vertical end of the pipe discharging into the open air. When the jet was impeded, in the funnel, by a cap of iron oxide, the gas rushing into the funnel would burn there, with the long pipe disconnected, but not when the long pipe was joined on. The experiments thus gave no distinct clue until observation of the brush discharge in the dark proved that frictional electricity was after all responsible. The hydrogen was escaping in a fine jet from a flange; a brush discharge several centimetres in length was observed which increased when the pipe was tapped to stir up the dust, and in the next moment explosion occurred.

When a copper wire, filed to a sharp point, was mounted on the flange with its axis in the jet in the gas, the brush discharge became hardly perceptible, and spontaneous ignition did not take place; but when the copper wire was bent off sideways, so as not to be in the path of the gas, the brush developed again and ignition once more occurred. Wrapping wire gauze round the flange did not stop the brush discharge.

Thus the accidents which suggested the investigation seem to be due to the friction between the hydrogen and the dust of iron oxide in the pipes and to the brush discharge from the electrified particles. One might wonder, however, why iron oxide should accumulate in steel cylinders and in pipes charged with hydrogen. But rusting is difficult to prevent in the presence of moisture, and Dr. Nusselt found as much as 300 grammes (more than half a pound) of iron rust in steel cylinders of a few litres capacity. In any case commercially pure hydrogen, free of dust, did not ignite when escaping. One additional observation made in the course of his investigation is of interest. It is well-known that radiations from radio-active substances ionise gases, and the ionisation is supposed to favour combination. Nusselt placed some thorium preparation in one of his steel vessels containing the explosive gas mixture; after a time he ignited the mixture by a spark and studied the instantaneous pressure curve. The ionisation did not appear to make any difference; but the experiments could not be pushed far, and the bombardment by the α particles from thorium may cause both combination and decomposition.

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.—An Exhibition of Contemporary British Architecture will be held in the Galleries of the Royal Institute, 9, Conduit Street, W. 1, from November 1st to December 16, next.

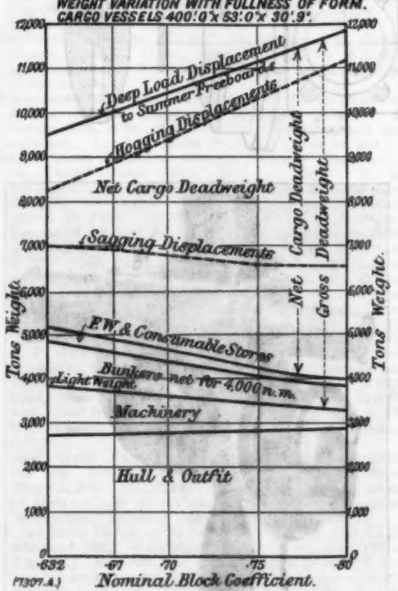
LONGITUDINAL STRENGTH OF CARGO VESSELS AND ITS VARIATION WITH FULLNESS OF FORM.*

By Mr. E. LESLIE CHAMPNESS, M.Sc.

§ 1. THIS paper presents the results of investigations carried out in the above subject as part of the tenure of the 1915 Post-Graduate Research Scholarship in Naval Architecture, awarded by the Commissioners of the Royal Exhibition, 1851, on the recommendation of the Council of this Institution. Owing to intervening circumstances, tenure of this scholarship did not begin until January, 1920, and the original intention to investigate shipyard operations, organizations and management abroad had to be abandoned, due to the changed conditions since the time of election.

§ 2. The subject of the relative strengths of fine and full vessels has been a matter of somewhat controversial discussion in the meetings of this Institution in past years, and for convenience a reference to the most important of these discussions, papers, or parts of papers bearing on the question is given in Appendix B.† The results of preliminary investigations on vessels of geometrical shape are given in Appendix A. The strength of vessels is intimately bound up with considerations of freeboard, and, as is well known, the Freeboard Tables, both those in force to-day and those proposed by the

Fig. 1. CURVES OF WEIGHTS ON BASE OF BLOCK COEFFICIENT.
WEIGHT VARIATION WITH FULLNESS OF FORM.
CARGO VESSELS 400'0"x 53'0"x 30'9".



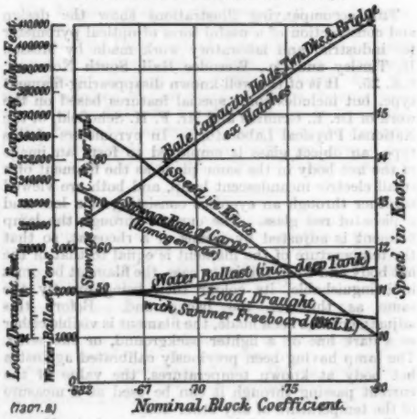
Load Line Committee of 1913–1916, allow in effect to some extent for the probable increase of bending moment in full vessels over that in fine vessels by the assignation of a higher freeboard and reduced draught, and consequently some reduction in the bending moment in fuller vessels, although this reduction in draught is primarily for another purpose. In the results here presented the freeboards have been determined to the requirements of the tables in the Load Line Committee Report of 1916, and the full results will therefore give some indication of the operation of these recommendations as far as the relative strengths of full and fine vessels are concerned. The variation of statical bending moment with difference in fullness of form is generally recognised and the work undertaken aimed at putting on record theoretical results showing the comparative quantitative variation in a particular and common type of merchant vessel under certain assumptions stated in full detail below. For the purpose of this investigation, it appeared that this object could be most clearly attained by taking a series of vessels, all of 400 ft. in length, with the same beam, depth and general arrangement, differing only in form and the consequent machinery weights, &c., for the speeds associated with the degree of fullness. A fixed length of voyage has been taken for all the vessels, and they are considered as laden in the load condition to their maximum legal draught in each scale. The particular length chosen is one at which the observed relation of height to length of wave is approximately equal to the assumed standard conditions, and in any case the severity or otherwise of the assumptions, operates to the same degree upon all the vessels concerned in the paper.

§ 3. The following extract from the Report of the Load Line Committee, 1916, expresses and summarises the position in which the question of fullness of form in relation to the longitudinal strength stands in present practice: "A study of the method of standardizing strength in this report will show that no account is taken of the effect of fullness or fineness of form in its relation to stresses." This method is based on an investigation of the rules of the Classification Societies. The practice of these societies for all ordinary vessels is not to regard differences in fullness, although for certain vessels which are of exceptional fineness special calculations are made. On the other hand, many designers of vessels work with stress figures based on previous experience, and with statical calculations for the particular vessel under consideration, which thus take account of fullness. From such calculations it appears that in vessels of identical dimensions, but of varying fullness, the statical bending moment is as a rule smaller in the finer vessel. It is argued, however, that the finer vessels are usually fitted with more powerful machinery, and may be driven against head seas in a manner which is impossible with the slower and fuller vessels, and that, consequently, finer vessels are subjected to greater dynamical stresses. "This subject should be investigated further, and one method which might possibly be useful would be actual strain experiments on ships at sea. Experiments of this nature have already been made, but not in sufficient numbers to establish their full value and utility. In present circumstances the Committee recommend the procedure in the report which, as stated, applies to seagoing cargo vessels of ordinary type."†

§ 4. As the results presented in this paper are quantitative, the remaining particulars of the series and the conditions and assumptions made in the calculations are given in detail below under their various headings.

(*a*) *Type of Vessel.*—The type of vessel chosen is indicated in the outline profile given in Figs. 5 and 6, on page 505, the general arrangement being the same for all the vessels, and consists of pure cargo-carrying type with two decks, and poop, bridge and forecastle, the combined lengths of which cover 50 per cent. of the vessel's length. The length of bridge in each case comes in to the "Long" category to Classification

Fig. 2. DESIGN PARTICULARS ON BASE OF BLOCK COEFFICIENT.
CARGO VESSELS 400'0"x 53'0"x30'.9".



Societies' designation. The vessels have full scantlings to Lloyd's Rules, 1920–21, and have transverse framing, the scantlings and their longitudinal extent being the same for the five vessels. The equipment and outfit is of normal amount suitable for vessels of the type taken.

(*b*) *Proportions.*—The dimensions of the vessels are as under, and may be considered as representative of present-day practice as far as the type chosen is concerned. All dimensions stated are moulded.

(L)	Length B.P.	= 400 ft. 0 in. $L/B = 7{\cdot}55$
	Length O.A.	= 415 ft. 6 in. or $B = L/10+13$.
(B)	Beam	= 53 ft. 0 in.
(D_u)	Depth	= 30 ft. 9 in. to upper deck at side. $L/D_u = 13$.
(D_b)	Depth	= 38 ft. 3 in. to bridge deck at side. $L/D_b = 10{\cdot}46$.
$\frac{B}{\text{Load Draught}}$		= 2·14 (average, varies with block coefficient).

(*c*) *Block Coefficient.*—The five vessels have block coefficients of 0·632, 0·67, 0·70, 0·75, and 0·80 respectively. The coefficients quoted above and as prefixed to the diagrams are nominal block coefficients at a draught = 0·85 of the depth to upper deck as used in the Load Line Committee Report of 1916. This nominal coefficient does not differ greatly from the normal block coefficient corresponding to the load draught, as may be seen from Table III. In all cases these coefficients have been calculated on moulded dimensions, and moulded displacements have been used throughout the calculations.

(*d*) *Form.*—In order that the distribution of the buoyancy longitudinally should conform to the most recent practice, the forms of the five vessels at the respective block coefficients have been designed with appropriate lengths of parallel middle body, and with their longitudinal centres of buoyancy in positions indicated by recent resistance results published in the transactions

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* Paper read before the Institution of Naval Architects, April 7, 1922.

† Pressure on our space prevents us from reproducing the Appendix B.

* See remarks. Trans. I.N.A., 1916, vol. lviii, page 43, by Dr. P. A. Hillhouse.

† Report of the Committee on Load Lines of Merchant Ships, 1916, page 17, § 91. See ENGINEERING, vol. ci, pages 348, 358.

of this and kindred institutions. The particulars of these forms are given in Table I. below, the mid-area coefficient being 0·98 for the series.

(*e*) *Draught.*—The fully loaded conditions from which the hogging and sagging conditions are arrived at are in each case for the vessels at their maximum summer draughts, with freeboards determined from the tables given in the Report of Load Line Committee, 1916, for a vessel of the type indicated, with steel deck, normal sheer, &c., and with erections as follows :—

TABLE I.

Nominal Block Coefficients.	Parallel Middle Body as Percentage of Length.	L.C.B. Forward or Midships at Load Draught (Still Waterline).	Parallel Midbody. Aft.	Parallel Midbody. Forward.
	per cent.		ft.	ft.
0·632 (parent form)	0	Amidships	0	0
0·67 (derived form)	10	Amidships	20	20
0·70 (derived form)	20	Amidships	40	40
0·75 (derived form)	35	1 per cent. of length forward	56	84
0·80 (derived form)	50	2 3 per cent. of length forward	72	128

TABLE III.

Nominal block coefficient	0·632	0·67	0·70	0·75	0·80
Normal block coefficient	0·625	0·66	0·696	0·75	0·80
Load draught, maximum summer freeboard to 1916 L.L. Committee	25′ 0″	24′ 11½″	24′ 9″	24′ 7½″	24′ 4½″
Corresponding load displacement in tons ..	9,462	9,977	10,402	11,174	11,810
Speed in knots (fair weather)	15	14	13	11½	10
Weight in tons :					
Hull and outfit	2,705	2,759	2,805	2,845	2,877
Machinery	1,152	980	827	588	434
Coal for 4,000 nautical miles	948	862	783	629	536
Fresh water, provisions and stores	300	280	250	200	140
	5,105	4,881	4,665	4,262	3,987
Load displacement	9,462	9,977	10,402	11,174	11,810
Balance, net cargo deadweight at load draught	4,357	5,096	5,737	6,912	7,823
Bale capacity, all holds and 'tween decks, including bridge, cubic feet	320,038	339,434	357,412	386,582	411,277
Stowage rate per ton in cubic feet for homogeneous cargo ..	73·5	68·7	62·4	55·9	52·6
Total water ballast capacity in tons, including deep tank ..	1,902	2,034	2,143	2,329	2,591

Fig. 3. MAXIMUM BENDING MOMENTS (STATICAL) AND SHEARING FORCES ON BASE OF BLOCK COEFFICIENT.

CARGO VESSELS 400′0″ x 53′0″ x 30′9″.

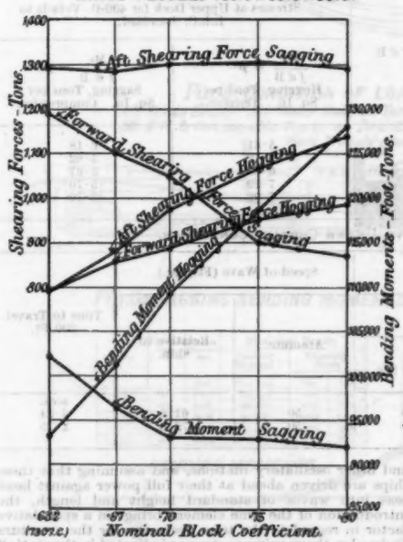
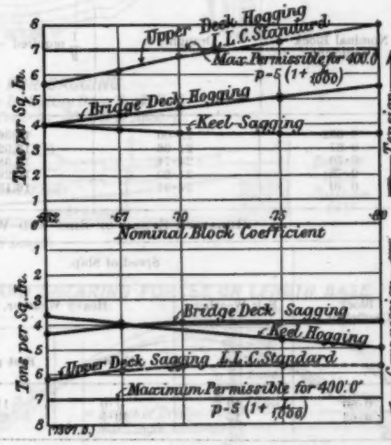


Fig. 4. MAXIMUM STRESSES (STATICAL) DUE TO BENDING MOMENTS.

CARGO VESSEL 400′0″ x 53′0″ x 30′9″.



Length of Ship Covered.	Effective Length of Erection Allowed with Closing Appliances Taken.
per cent.	per cent.
Poop 10	100
Bridge 30	80
Forecastle 10	100

The freeboards so assigned show practical agreement with those to the existing freeboard regulations as given above in Table II., in which the maximum summer draughts are compared. The modification of the results given to constant draught is a simple matter.

(*f*) *Speed of Vessels.*—A speed of vessel for each of the block coefficients chosen has been assigned as given in Table III., appropriate to the fullness of vessel, and within the region of average practice for economical propulsion in cargo vessels.

(*g*) *Weights.*—The weights have been calculated as detailed under the various headings in Table III, and have been distributed per frame-space of length of vessel for each case. The totals for each of these items at the different block coefficients are given in Table III.

(*h*) *Hull.*—Calculations of weight of structure have been made in detail from the scantlings before mentioned, and distributed per frame-space so as to take accurate account of the variation in hull weight due to variation in fullness of form.

(*j*) *Machinery.*—Average powers for the displacements and speeds as above have been calculated in each case, and the total machinery weights have been taken on a basis of 4·6 I.H.P. per ton, as being representative of modern practice with reciprocating machinery and with cylindrical boilers, covering the majority of vessels of the type chosen.

(*k*) *Fuel.*—For the purpose of these calculations, a voyage of 4,000 nautical miles has been taken for each vessel, and with coal as the fuel, the necessary bunkers for the particular speeds and powers assigned as above have been taken at a rate of 1·5 lb. per I.H.P. per hour, with no further margin for bad weather or for harbour or other uses. The coal is taken as evenly distributed alongside the boiler-room.

(*l*) *Fresh Water and Consumable Stores.*—Weights appropriate to the powers and length of voyage have been allocated to each vessel and are distributed in the midship region.

(*m*) *Cargo.*—The net cargo deadweight available to bring the vessel to the Load Draught specified in para. (*e*) above (*i.e.*, deep load displacement *less* light weight bunkers, fresh water, and stores) has been distributed, homogeneously in the cargo space (bale) at each separate block coefficient. The space available for cargo has been taken as : All holds (*ex* hatchways), 'tween decks main to upper, and the bridge 'tween decks. The poop space is allocated to crew accommodation, and the forecastle to the permanent ship's stores and are not included in the cargo spaces. These capacities, together with the resulting stowage rates per ton for homogeneous cargo in each case are given in Table III.

(*n*) *Water Ballast.*—The spaces in the design available for the carriage of water ballast and used in the strength calculations for the sagging conditions are as follows for each ship :—(i) Double-bottom tanks of normal rule depth extending from after peak bulkhead to collision bulkhead, and including under machinery spaces. (ii) Fore peak tank extending to main deck level, 29 ft. long ; (iii) After peak tank extending to main deck level,

TABLE II.

Nominal Block Co.	Maximum Summer Draughts. To 1916 L.L. Committee.	Maximum Summer Draughts. To Existing Regulations with Sheer.
	ft. in.	ft. in.
0·632	25 0	24 11
0·67	24 11½	24 10½
0·70	24 9	24 9½
0·75	24 7½	24 7½
0·80	24 4½	24 4½

22 ft. long ; (iv) Deep tank (No. 3 hold), extending to main deck level, 30 ft. 6 in. long, has been included, as this feature of design leads to more severe sagging conditions in the "ballast and bunker" condition than in vessels with double bottoms and peaks only for water ballast. The weights and particulars of the various items detailed in paras. (*e*) to (*n*) above are summarised in Table III., and shown graphically in Figs. 1 and 2.

§5. The statical strength calculations have been carried out on the assumptions usual in such calculations, viz., with the vessels balanced on trochoidal waves of length equal to the length of the ship and of height equal to one-twentieth of the length, wave crest amidships for hogging and wave hollow amidships for sagging, the vessel being assumed upright and the course of ship at right angles to the lines of wave crests. The wave profiles shown in Figs. 5 and 6, show the position of the wave surface at block coefficients of 0·80 (hogging) and 0·63 (sagging), in which the wave surface is nearest the deck level for this series of vessels. It will be observed that in no case does the standard wave waterline come above the enclosed structure of the vessels. The curves of shearing force and bending moment for each case have been obtained by use of the integraph from load curves derived from weight and buoyancy curves in the usual manner. The bending moments amidships have also been calculated direct in each case by moment calculations as a check, without the use of the integraph. The conditions of the vessels in which the strength has been investigated have been taken as under :—

(*a*) *Hogging.*—All holds and 'tween decks, bridge 'tween decks full of homogeneous cargo (of amount equal to that carried in loaded condition). All coal burnt out. All fresh water and consumable stores out. No water ballast. (A condition corresponding to a possible arrival condition.)

(*b*) *Sagging.*—In investigating the sagging strength amongst waves, it was not immediately obvious (as is more or less the case in hogging) which normal service condition would give the most severe bending moment with wave hollow amidships. Three sagging conditions were therefore worked out for the vessel with 0·70 block coefficient in order to determine this. The details of these three conditions are as follows :—A. Light condition, no cargo, but with bunkers full, and fresh water and consumable stores all aboard. B. As A, but with all water-ballast tanks (as para. (*n*)), including deep tank, full—this being considered a normal "ballast and bunker" condition. Any intermediate condition with certain ballast tanks only, such as midship bottom tanks and deep tank full, has been excluded as involving an uneconomic provision of such spaces. C. Deep load condition (departure), *i.e.*, all cargo, coal, fresh water, and stores aboard, no water ballast. The resulting statical bending moments amidships for these three cases were found to be as given in Table IV, below, from which it may be seen that condition B is the most severe, and

TABLE IV.—*Sagging Bending Moments Amidships. Block Coefficient* = 0·70.

Condition.	Sagging Displacement.	Bending Moments.
	tons	ft.-tons
A. Light, in bunkers	4,665	79,410
B. Light, bunkers and ballast	6,808	91,690
C. Deep load	10,402	76,340

conditions similar to this have therefore been assumed in calculating the sagging bending moments of the remaining vessels of other block coefficients. The design investigated has included a deep tank, so that the sagging results obtained may be those for the most severe sagging conditions likely to be found in a vessel of this type. The sagging bending moments for similar ships without a deep tank would be appreciably less. The inclusion of this feature does not affect the hogging results in any way, as this compartment is assumed full of cargo in that condition.

§6. *Results.*—The statical results obtained in the calculations are set out in Tables V. and VI., and in Fig. 3 as far as the maximum values are concerned, whilst the variation of bending moment and shearing force over the length for the series of five vessels in the hogging and sagging conditions is given in Figs. 5 and 6 on page 505.

§7. *Stresses.*—The bending moment results obtained

have been translated into stresses by the use of the usual beam formula, as conveying something more tangible for comparison with other results obtained similarly, bearing in mind the assumptions taken in the calculations. The stresses quoted in Tables V, VI, and VII, and shown in Fig. 4, are those due to the longitudinal bending moments only, and do not include those due to fluid pressure, etc.

The full curves in Fig. 4, and the results in cols. 6 and 7 of Tables V and VI are the stresses determined for a midship section to scantlings as para. (*a*). The moment of inertia of section is the same for each of the vessels, and is calculated without deductions for rivet holes or for deck openings, and includes the sides and deck of bridge. Gunwale angle and sheerstrake extension above bridge deck have been included, and all continuous material longitudinally has been taken account of as usual. The stresses designated "Keel" and "Deck" are for the following points: (*a*) Keel, bottom of flat plate keel (0·14 ft. below moulded line); (*b*) Deck, top of bridge deck stringer at side (0·04 ft. above moulded line). The total moment of inertia of section for each vessel determined as above is 471,280 sq. in. × ft.^{2} Calculated position of neutral axis is 18·24 ft. above moulded base line. Distance of furthest fibres from neutral axis, *y* to keel as (*a*) = 18·38 ft. *y* to deck as (*b*) = 20·05 ft.

The stresses at strength deck (upper deck), with section moduli in accordance with the standard of longitudinal strength laid down by the Load Line Committee Report, are indicated by dotted lines in Fig. 4, and are given in Table VII. The maximum permissible stress for 400-ft. vessels, obtained from the equation

$$p = 5\left(1 + \frac{L}{1000}\right),$$

is 7 tons per square inch.* The modulus of resistance

$$= \frac{I}{y} = f\,d\,B = \frac{M}{p},$$

where *d* = draught in feet top of keel to centre of disc in S.W. (summer freeboard).

B = breadth in feet.

f = longitudinal strength factor = 12·50 for 400-ft. vessel (p. 35, L.L.C. Report, 1916).

y = distance of underside of strength deck stringer from neutral axis.

Vessels' proportions are within the limits to which the recommendations apply.

The value of the stresses in Table VII are higher than those in Tables V and VI on account of the $\frac{I}{y}$ value being taken to the upper deck in one case, and to the bridge deck in the other.

The $\frac{I}{y}$ values to deck, of the section to Lloyd's rules used, were:—

23,500, including bridge.
16,420 to upper deck, omitting bridge, using scantlings of topsides and upper deck in way of bridge.
18,850 to upper deck, omitting bridge, using scantlings of topsides and upper deck, clear of bridge.

§ 8. *General Conclusions.*—It will be seen from the tables given that, as far as statical results are concerned for the vessels considered, there is an increase of 37·6 per cent. in the hogging bending moment and stresses in the full vessel of 0·80 coefficient compared with the fine vessel of 0·63 coefficient, and the increase in bending moment is approximately proportional to the increase in displacement throughout the series (*see* col. 4 of Table V). This difference in stresses is increased to 41·2 per cent. when the same bending moments are considered as acting upon midship sections to the standard of strength proposed by the recent Load Line Committee, owing to the section modulus required by that standard of longitudinal strength being based on draught (*see* Table VII). The hogging bending moment may be seen to be considerably in excess, for the full vessel, of the bending moment in the extreme sagging condition chosen, and the ratio of hogging to sagging bending moments decreases with fining of the vessel. It should be borne in mind that these sagging results include a full deep tank amidships of approximately the same capacity in all the vessels (1,010 tons for 0·63 coefficient and 1,074 tons for 0·80 coefficient). This feature also accounts for the constancy of the maximum shearing force aft (sagging) in all the vessels of the series.

As a deep tank of this size is not a usual feature in fine vessels, it is probable that the statical hogging bending moments will in general be in excess of the statical sagging moments in all cargo vessels of ordinary type and arrangement, with machinery amidships. The liability to greater sagging moments in fine vessels leads to greater compressive stresses in the deck which, if excessive, would be more likely to show themselves in the structure than would similar increases in tensile stresses. Attention to the number and spacing of deck girders in the midship portion is therefore of relatively more importance in fine vessels than in fuller vessels with the same scantlings. These compressive stresses in the upper works are also augmented by the similar stresses caused by pounding, which are also most severe when the vessels are in the light conditions corresponding to the most severe sagging condition for longitudinal bending. The results given will be modified by heaving and pitching, but such modifications will affect chiefly the sagging results, as far as increases in bending moment of any appreciable size are concerned. In view of the usual conception of the maximum shearing forces occurring at about the quarter-length positions, attention may be called to the positions of the maximum shearing forces forward in the sagging condition on Fig. 6.

* Trans. I.N.A., 1916, Vol. LVIII, p. 51, Sir W. S. Abell. *See* ENGINEERING, Vol. CI, p. 361.

The range of maximum shearing force forward from the hogging to sagging condition at the different coefficients may be seen from Figs. 5 and 6.

§ 9. *Type of Ship.*—It will be noted that no attempt has been made to vary the type of ship at different block coefficients. In actual practice it is likely that the vessels of finer form and higher speed would carry a certain number of passengers in the midship region. Such arrangements would add more weight amidships, and consequently reduce the weight available for cargo, thereby increasing the sagging and reducing the hogging bending moments for the same draughts, and accentuating to some extent the differences between the fine and full vessels shown in the curves of bending moments on a base of block coefficients (Fig. 3). The quantitative results are not altered to any appreciable extent by supposing the cargo-carrying type to be a single decker instead of the two-deck type chosen.

§ 10. *Extent of Maximum Bending Moment (Statical).*—The extent of parallel mid-body has been indicated on Figs. 5 and 6 as affording some indication (after correction in depth for sheer) of the region of maximum stresses amidships due to the statical bending moments, when considered in conjunction with the bending moment curves. The length of bridge in the particular case investigated has also been shown on these figures for a similar reason. Mr. A. M. Robb has shown that for a vessel of the mixed intermediate type, of 340 ft. length and block coefficient of 0·67, the maximum hogging bending moment curve for the wave crest amidships is an envelope of the curves of bending moment with the wave crest at other positions along the length of ship.* It may be mentioned as bearing upon the question of fullness that a similar result has been found for a vessel of widely different characteristics, namely, a modern destroyer of 265 ft. length, and of fine form—the statical results only being considered.

§ 11. *Effect of Speed.*—The contingency of vessels being driven heavily into head seas is a matter depending upon the human element, but it may be considered reasonable to presuppose that a sensible degree of nursing and easing down takes place in general practice with merchant vessels in heavy weather conditions. It is useful to recall that the standard waves used in this particular set of calculations, 400 ft. × 20 ft., are waves such as would be found, from observed data, in weather conditions corresponding to a wind force of about 8–9 Beaufort scale, *i.e.*, a moderate to strong gale with a wind of about 40 m.p.h. to 50 m.p.h., and that a consensus of sea-going opinion indicates that proceeding at full power, even in slow speed cargo vessels, is unusual in such conditions, and that normal procedure is to ease the ship down to comfortable speed. War-craft and vessels having an exact time function to fulfil might be expected to be forced on occasion, but this does not apply to ordinary cargo vessels, and in any case the strength of such vessels is in general a matter of special calculation, and outside the scope of this paper.

§ 12. *Time Element.*—Neglecting pitching, heaving and other oscillatory motions, and assuming that these ships are driven ahead at their full power against head seas into waves of standard height and length, the introduction of the time element brings in a speculative factor in regard to the time necessary for the structure to develop the maximum stresses indicated in the statical calculations. The 400-ft. waves must necessarily be associated with their observed speed of propagation, and waves of this length in regular series have been noted by various observers in association with a speed of about 55 ft. per second, whilst a speed of 45·3 ft. per second is given by the trochoidal wave theory for a 400-ft. wave. Taking the speed of wave as 50 ft. per second, and considering the 10-knot full vessel (0·80 block coefficient) and the 15-knot fine vessel (0·63) coefficient to be reduced owing to weather conditions to speeds of 7 knots and 13½ knots respectively, the relative speeds of ship and wave in the two cases are tabulated above.

Theoretically, therefore, the wave crest would pass from the stem to midships in 3 seconds or under, that is to say, the deck amidships, for instance, would pass from tension to compression maxima, or *vice versa*, in that time, or from zero to maximum stress in about 1½ seconds when steaming into a regular series of such waves, such changes being easy and not impulsive. Owing to the transitory nature of the load, it would seem probable that in a complex structure, such as a ship with so many component parts and connections, the maximum theoretical stress might hardly have time to develop the full intensity in the structure indicated by the statical calculations, and also that there might be some time-lag present. This diminution of stress might be

* Trans. I.N.A., 1918, vol. lx, page 188; ENGINEERING, vol. cv, page 362.

TABLE V.—HOGGING.

Nominal Block Coefficient.	Displacement in Tons, W.	Bending Moments. Maximum, M_h Foot-Tons.	$C = \frac{W.L.}{M_h}$	Per Cent. Increase over M_h at 0·632.	Stresses in Tons/sq. in. C. Keel.	C. Bridge Deck.	T. Keel.	T. Bridge Deck.	Shearing Forces. Maximum, S. Tons. Forward.	Tons. Aft.	$C = \frac{W}{S_{max.}}$
0·632	8,214	92,900	35·4	—	3·62	3·95	786	788	10·42		
0·67	8,835	101,100	34·9	+ 8·8	3·94	4·30	856	877	10·07		
0·70	9,369	109,200	34·3	+17·6	4·26	4·65	884	974	9·62		
0·75	10,345	118,700	34·9	+27·8	4·62	5·05	953	1,065	9·72		
0·80	11,134	127,800	34·9	+37·6	4·98	5·44	986	1,138	9·80		

TABLE VI.—SAGGING.

Nominal Block Coefficient.	Displacement in Tons, W.	Bending Moments. Maximum, M_s Foot-Tons.	$C = \frac{W.L.}{M_s}$	Per Cent. Decrease from M_s at 0·632.	Stresses in Tons/Sq. In. T. Keel.	T. Bridge Deck.	C. Keel.	C. Bridge Deck.	Shearing Forces. Maximum, S. Tons. Forward.	Tons. Aft.	$C = \frac{W}{S_{max.}}$
0·632	7,007	102,200	27·4	—	3·98	4·35	1,186	1,288	5·44		
0·67	6,915	96,200	28·7	− 5·9	3·75	4·09	1,100	1,279	5·41		
0·70	6,808	92,800	29·4	− 9·2	3·62	3·95	1,052	1,206	5·26		
0·75	6,591	92,800	28·4	− 9·2	3·62	3·95	895	1,306	5·05		
0·80	6,578	92,000	28·6	−10·0	3·59	3·92	870	1,292	5·09		

TABLE VII.

Nominal Block Coefficient.	Draught, *d*.	$\frac{I}{y}$ required $= f\,d\,B$.	Stresses at Upper Deck for 400-ft. Vessels to L.L.C. Standard. $\frac{M_h}{f\,d\,B} = p_h$. Hogging, Tons per Sq. In. Tension.	$\frac{M_s}{f\,d\,B} = p_s$. Sagging, Tons per Sq. In. Compression.
0·632	25·00	16,560	5·61	6·18
0·67	24·96	16,520	6·12	5·82
0·70	24·74	16,380	6·68	5·67
0·75	24·60	16,290	7·29	5·70
0·80	24·37	16,130	7·92	5·70

RELATIVE SPEED OF SHIP AND WAVE UNDER CERTAIN CONDITIONS.

Block Coefficient.	Speed of Ship. Fair Weather. Knots.	Heavy Weather. Knots.	Heavy Weather. Feet per Sec.	Speed of Wave (Ft./Sec.). Absolute.	Relative to Ship.	Time to Travel 200 Ft.
						secs.
0·80	10	7·0	11·8	50	61·8	3·24
0·63	15	13·5	22·8	50	72·8	2·75

expected to be greater in the finer and faster vessel owing to the shorter time elapsing between the maximum stress positions as already pointed out. It may be quoted as an analogy bearing to a limited extent upon this effect, that it is possible to skate with safety over thin ice quickly, where a dead load of similar amount could not be borne. ¶ 12. 67

The diagram (Fig. 6b) (which is not to scale, but preserves some relative proportions) illustrates the stresses on a time base for a particular point in the structure, the full lines represented the stresses as calculated in the statical positions for a particular condition of loading, whilst the dotted lines indicate the probable stresses under the above assumptions. Evidence of this feature in the numerous stress and strain experiments with rolling loads in land structures, such as bridges,* is complicated by the presence of the more serious "impact effect" experienced in them due to character of the moving load, and also by the difference in character of the stresses present and the fixity of ends in bridge work. The results presented by Mr. W. R. G. Whiting of the observed strains during the launch of a battleship, using the Foster Strainmeter, show features which might bear out this supposition.†

Theoretical argument can indicate tendencies only, and practical measurement of stresses at sea in known weather conditions is required to establish such points as to whether this propagation of a series of stress waves through the structure at, more or less, regular intervals of time gives rise to any superimposed stresses in a free-ended support, such as a ship on a wave, and also to measure the superimposed stresses which must occur due to impulsive blows of the sea upon the bottom forward and due to vibration.

The attention of those interested may be drawn to the Fereday-Palmer Stress Recorder, which has been used in recent bridge experiments, and which records the rapidly varying stresses occurring in such structures by means of light acting upon a photographic film. This instrument appears to be a development in stress-recording apparatus which would assist in the carrying out of such stress experiments under the conditions prevailing at sea.*

§ 13. *Conclusion.*—The results given in this paper are mainly statical, and no account has been taken of "Smith" effect, pitching, heaving, or rolling, which, of course, cause some modification of the results. To this extent, therefore, the paper is in the nature of an interim report, and it is hoped that the research may be completed in the near future by presenting the results

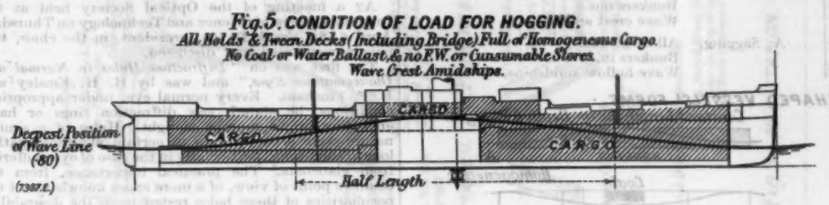
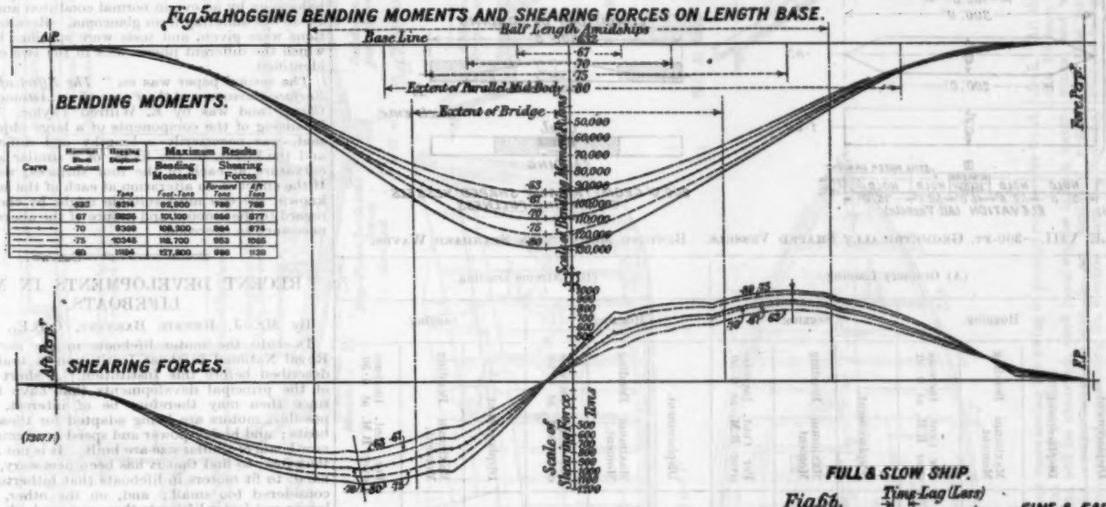
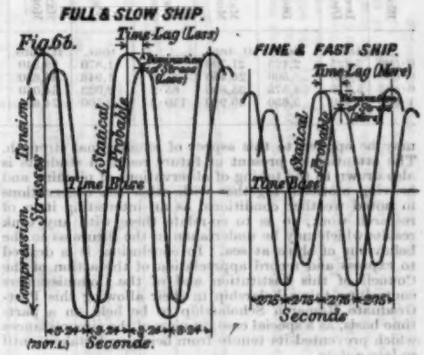


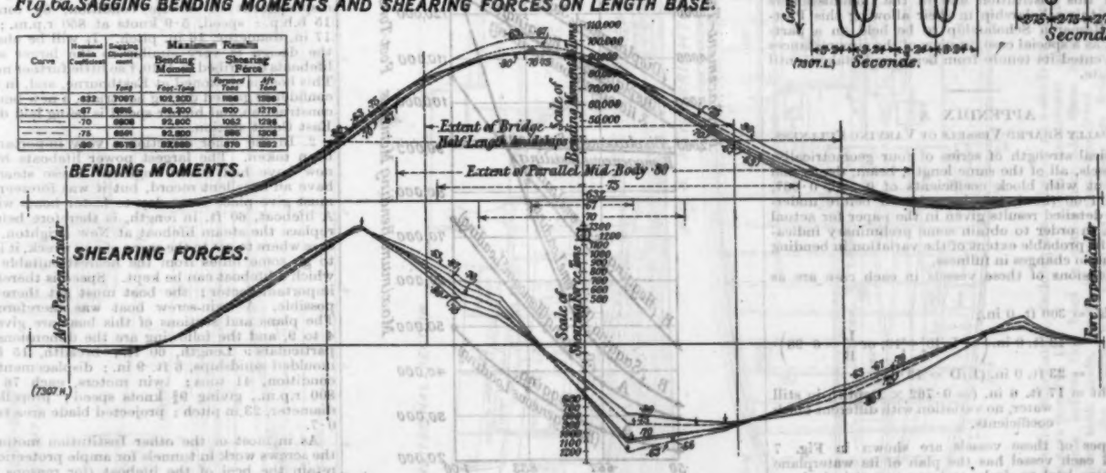
Fig. 5. CONDITION OF LOAD FOR HOGGING.
All Holds & Tween Decks (Including Bridge) Full of Homogeneous Cargo.
No Coal or Water Ballast, & no F.W. or Consumable Stores.
Wave Crest Amidships.



Curve	Nominal Block Coefficient	Sagging Displacement	Maximum Results	
			Bending Moments	Shearing Forces
		Tons	Foot-Tons	Forward Tons / Aft Tons
	·632	6374	95,600	798 / 798
	·67	6826	104,100	866 / 877
	·70	6368	108,300	894 / 874
	·75	10345	118,700	953 / 1065
	·80	11264	127,800	998 / 1120

Fig. 6. CONDITION OF LOAD FOR SAGGING.
All Holds Empty: All Water Ballast Tanks Including Deep Tank Full.
All F.W. & Consumable Stores on Board: Coal for 4000 N.M. Aboard.
Wave Trough Amidships.
F.W. & STORES
COAL AT SIDES
WATER BALLAST
WATER BALLAST
DEEP TANK
Deepest Wave Position (·63)
Half Length
(7307.G.)





Curve	Nominal Block Coefficient	Sagging Displacement	Maximum Results	
			Bending Moment	Shearing Force
		Tons	Foot-Tons	Forward Tons / Aft Tons
	·632	7097	101,300	1086 / 1286
	·67	6995	98,300	1020 / 1278
	·70	6908	93,600	1052 / 1288
	·75	6691	93,600	986 / 1308
	·80	8078	93,600	870 / 1302

* For recent information and references to previous experiments, see Proc. Inst. C.E., vol. cc, pages 178 *et seq.*, Mr. C. W. Anderson; and Trans. Amer. Soc. of C.E., vol. lxxxii, page 1040 *et seq.*, Dr. D. B. Steinman, 1918.

† Trans. I.N.A., 1914, vol. lvi, Fig. 6. Plate X., ENGINEERING, vol. xcvii, page 489.

* See description and results, Ministry of Transport Report, 1921, "Tests on Railway Bridges in Respect of Impact Effect," and recent report of Indian Railway Bridge Committee, 1922.

of taking into account the dynamical effects of pitching and heaving, together with the correction for wave motion and pressures, so as to cover the problem more fully for the series of vessels here dealt with. In so doing it is very desirable that the knowledge of the extent of pitching and heaving may not depend solely on the mathematical results now available, but that experimental tank results giving the observed results of resisted pitching and heaving motions amongst waves of known character for varying speeds of vessel may be undertaken, and that such experiments should include a series of models of varying fullness so that the results may be applied to this aspect of longitudinal strength. The attention of present or future research students is also drawn to the taking of observations of pitching and heaving motions, together with other sea observations in noted weather conditions, as an interesting item of research work, so as to co-relate these with any tank results which may be undertaken in the future as to the behaviour of ships at sea. In conclusion, it is desired to express and record appreciation of the action of the Council of this Institution and of the Commissioners controlling this scholarship in their allowing this Post-Graduate Research Scholarship to be held on a part-time basis, as a special case, in view of the circumstances which prevented its tenure from being undertaken until so late a date.

APPENDIX A

Geometrically Shaped Vessels of Varying Fullness.

The statical strength of series of four geometrically-shaped vessels, all of the same length, beam, depth and draught, but with block coefficients of 0·500, 0·667, 0·833 and 1·00 (box), was investigated before undertaking the detailed results given in the paper for actual ship forms, in order to obtain some preliminary indication as to the probable extent of the variation in bending moment due to changes in fullness.

The dimensions of these vessels in each case are as follows:—

Length = 300 ft. 0 in.,

Beam = 43 ft. 0 in. $\left(= L/10 + 13, \text{ or } \frac{L}{B} = 6 \cdot 98\right)$,

Depth = 23 ft. 0 in. (L/D = 13·04),

Draught = 17 ft. 6 in. (= 0·762 × Depth), in still water, no variation with different block coefficients.

The shapes of these vessels are shown in Fig. 7 above, and each vessel has the plan of its waterplane constant from keel to deck, and is symmetrical about midships.

The machinery weights (400 tons) and the bunker weights (800 tons) have been assumed constant throughout the series, and are situate amidships occupying 15 per cent. of the vessel's length.

The variation in hull weight due to the form of vessel has been taken into account, but no reduction in scantlings at ends has been allowed for.

The strength has been worked out for the vessels balanced on the usual standard trochoidal waves of length = 300 ft., height = L/20 = 15 ft.

Two conditions of loading have been assumed, and the maximum hogging and sagging bending moments amidships calculated for each.

The first condition is the usual, viz.:—

A. Hogging. All cargo in, homogeneously distributed in all holds.
Bunkers out.
Wave crest amidships.

A. Sagging. All cargo out.
Bunkers in.
Wave hollow amidships.

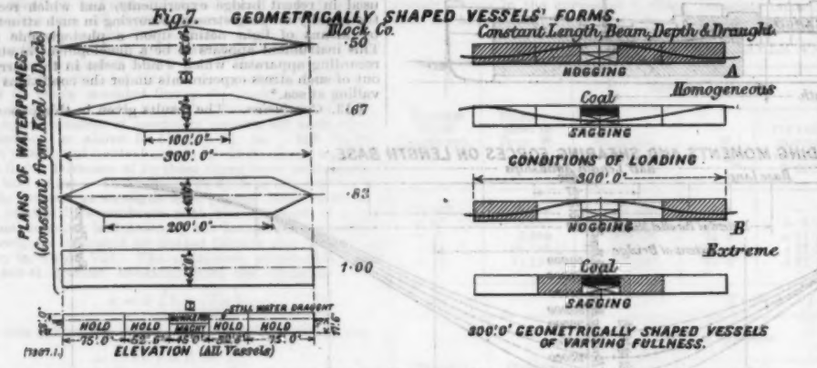
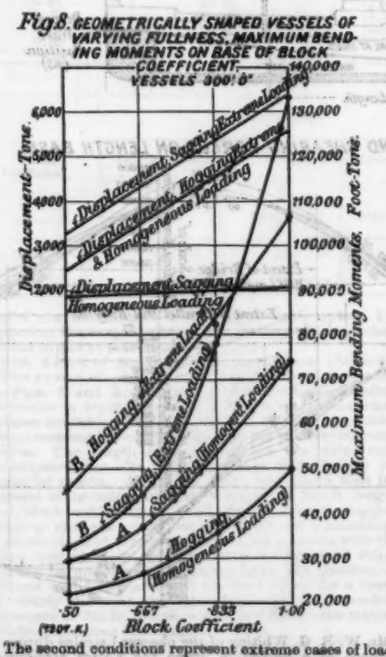


TABLE VIII.—300-ft. Geometrically Shaped Vessels. Bending Moments on Standard Waves.

Block Coefficient.	Deep Load Displacement.	(A) Ordinary Loading. Hogging. Displacement.	Maximum Bending Moment.	Per Cent. Increase over B.M. at 0·50.	Sagging. Displacement.	Maximum Bending Moment.	Per Cent. Increase over B.M. at 0·50.	(B) Extreme Loading. Hogging. Displacement.	Maximum Bending Moment.	Per Cent. Increase over B.M. at 0·50.	Sagging. Displacement.	Maximum Bending Moment.	Per Cent. Increase over B.M. at 0·50.
	tons.	tons.	ft.-tons.	—	tons.	ft.-tons.	—	tons.	ft.-tons.	—	tons.	ft.-tons.	—
0·500	3,225	2,425	21,700	—	1,870	29,540	—	2,425	45,410	—	3,225	31,840	—
0·667	4,300	3,500	26,450	21·9	1,946	36,680	24·2	3,500	66,420	46·3	4,300	44,560	40·0
0·833	5,375	4,575	35,830	65·2	2,023	54,040	83·0	4,575	82·570	81·9	5,375	77,930	144·8
1·000	6,450	5,650	49,090	130·3	2,100	74,600	152·7	5,650	107,090	136·0	6,450	125,720	320·0



The second conditions represent extreme cases of loading, viz.:—

B. Hogging. All cargo in, but concentrated in the two end holds.
Bunkers out.
Wave crest amidships.

B. Sagging. All cargo in, but concentrated in the two midships holds.
Bunkers in.
Wave hollow amidships.

The resulting maximum bending moments amidships for these four cases for the four vessels are shown in Fig. 8, and in Table VIII on this page.

THE OPTICAL SOCIETY.

At a meeting of the Optical Society held at the Imperial College of Science and Technology on Thursday, April 6, Sir Frank Dyson, president, in the chair, two papers were read and discussed.

The first was on "*Diffraction Halos in Normal and Glaucomatous Eyes*," and was by H. H. Emsley and E. F. Fincham. Every normal eye, under appropriate conditions, he stated, saw diffraction rings or halos encircling bright sources of light. Halos of a similar nature were seen by eyes in certain abnormal pathological conditions, particularly in the case of eyes suffering from glaucoma. The practical importance, from the oculist's point of view, of a more exact knowledge of the peculiarities of these halos rested upon the desirability of being able to differentiate with certainty between the halos seen by an eye in normal condition and those seen by an eye suffering from glaucoma. Results of observations were given, and tests were specified by means of which the different phenomena in the two cases may be identified.

The second paper was on "*The Effect of Changes on Surface Curvature at the Focus of an Astronomical Object Glass*," and was by E. Wilfred Taylor. The correct balancing of the components of a large object glass, he said, was necessarily a lengthy and difficult process, and the effect, at the focus, of a similar alteration of curvature at each of the four surfaces, was different. If the effect of an alteration at each of the surfaces were known, the one most suitable might be chosen, having regard to the amount and nature of the aberration it was necessary to overcome.

RECENT DEVELOPMENTS IN MOTOR LIFEBOATS.*

By Mr. J. Rennie Barnett, O.B.E., Member.

In 1910 the motor lifeboats in the service of the Royal National Lifeboat Institution at that date were described before this Institution. A short description of the principal developments that have taken place since then may therefore be of interest. Wherever possible, motors are being adapted for these coast lifeboats; and higher power and speed are demanded when new boats of similar size are built. It is not astonishing, therefore, to find that it has been necessary, on the one hand, to fit motors in lifeboats that hitherto have been considered too small; and, on the other, to provide larger and faster lifeboats than any yet built.

1. Until the year 1921 the smallest motor lifeboats built were as follows: (A) Self-righting boats, 38 ft. by 9 ft. 9 in. Motor developing 35 b.h.p. at 750 r.p.m.; speed, 7 knots. (B) Non self-righting boats, 38 ft. by 10 ft. Motor developing 34 b.h.p. at 700 r.p.m.; speed, 7·15 knots. But it had long been hoped to produce a motor lifeboat small enough for transporting on a carriage, and this has now been done. It was feared that the impossibility of damage to the propeller, and straining of the boat affecting the machinery, might prove difficult to overcome. But a 35-ft. self-righting carriage motor lifeboat has been built, and so far has proved quite successful. The lines of this boat are shown in Figs. 1 to 3, and the following are the dimensions and chief particulars: Length, 35 ft.; breadth, 8 ft. 6 in.; displacement in service condition, 6¼ tons; motor, 15 b.h.p.; speed, 5·9 knots at 850 r.p.m.; propeller, 17 in. diameter, 16 in. pitch. It will be observed that the design is very similar to the larger self-righting lifeboats described in 1910,† so little further need be said. This boat is stationed at Eastbourne, and, in view of the confidence gained during her trials, a new boat of lighter construction and higher speed is being laid down for an East Coast station.

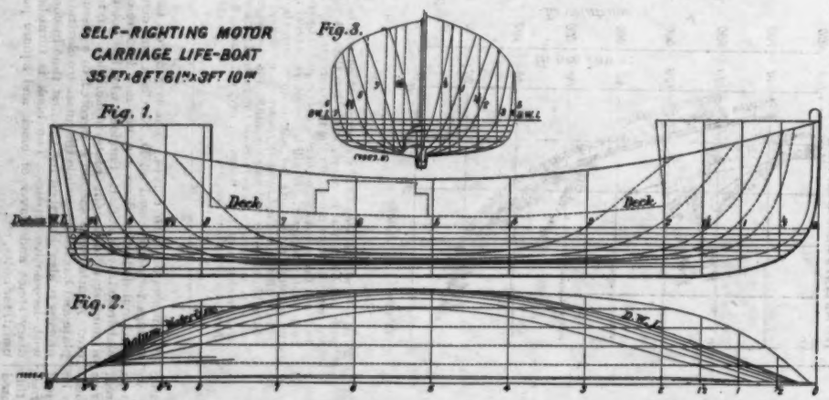
2. In the other direction a very important step has been taken. The largest power lifeboats built up till now have had steam engines. These steam lifeboats have an excellent record, but it was foreseen that they must give place some day to faster boats with motors. A lifeboat, 60 ft. in length, is therefore being built to replace the steam lifeboat at New Brighton. This is a case where to get to the scene of any wreck, it is necessary to go some miles from the nearest suitable station at which a lifeboat can be kept. Speed is therefore a most important factor; the boat must get there as fast as possible. A twin-screw boat was therefore designed. The plans and sections of this boat are given in Figs. 4 to 9, and the following are the dimensions and chief particulars: Length, 60 ft.; breadth, 15 ft.; depth moulded amidships, 6 ft. 9 in.; displacement in service condition, 41 tons; twin motors, each 76 b.h.p., at 800 r.p.m., giving 9¾ knots speed; propellers, 26 in. diameter, 23 in pitch; projected blade area to disc area, 0·7.

As in most of the other Institution motor lifeboats, the screws work in tunnels for ample protection; and to retain the heel of the lifeboat (for reasons previously explained) it is necessary to continue the keel right aft to the stern post, and build a deadwood dividing the two tunnels. This being a peculiar design, and the appendages being abnormal in size and in other directions, the model was tested in a tank. Our good friends, Messrs. Denny, in most generous fashion took great pains testing this model, and confirmed the design as being satisfactory for the condition laid down. They also tested the

* Paper read before the Institution of Naval Architects, April 7, 1922.

† See Engineering, vol. lxxxix, page 411.

RECENT DEVELOPMENTS IN MOTOR LIFEBOATS.



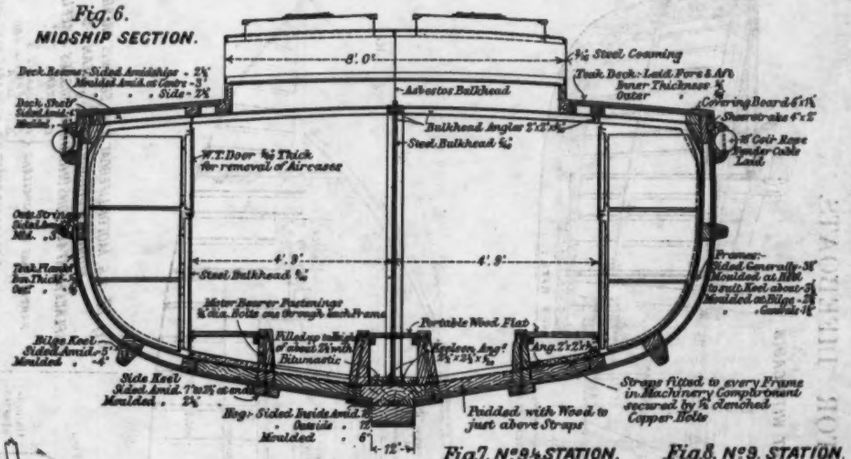


Fig. 6.
MIDSHIP SECTION.
Asbestos Bulkhead.
Steel Bulkhead.
Portable Wood Flat
Straps fitted to every Frame in Machinery Compartment secured by ⅝ clenched Copper Bolts
Padded with Wood to just above Straps

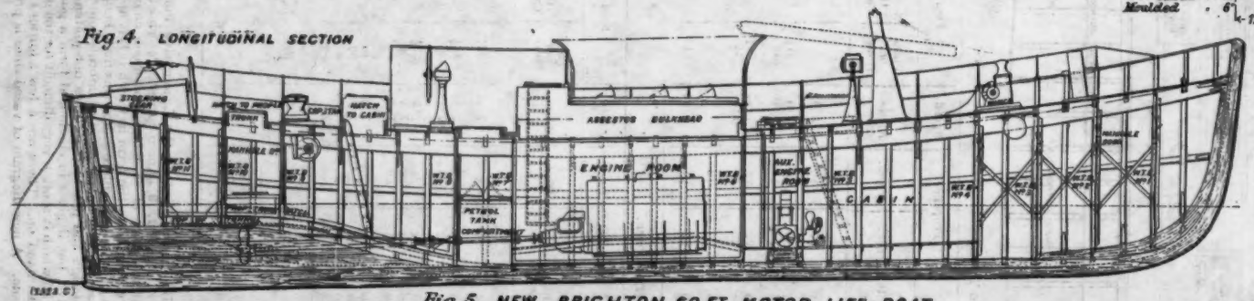
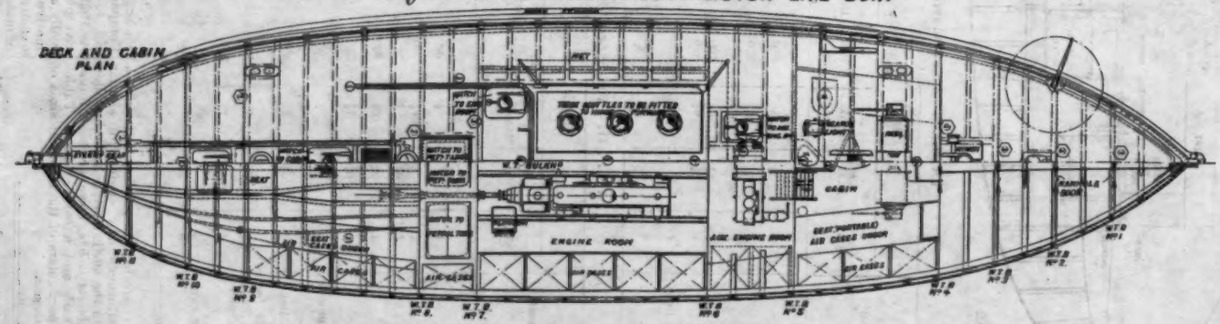


Fig. 5. NEW BRIGHTON 60 FT. MOTOR LIFE-BOAT



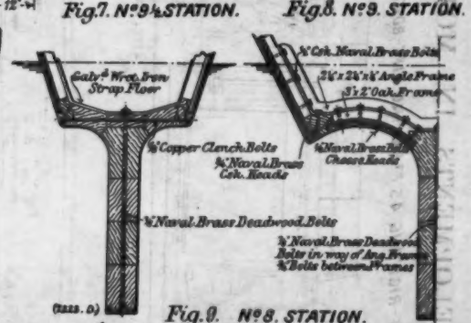


Fig. 7. No. 9½ STATION.
Fig. 8. No. 9. STATION.
Galv.d Wrot. Iron Strap Floor
⅝ Copper Clench Bolts
¾ Naval Brass Cch. Heads
¾ Naval Brass Deadwood Bolts
¾ Cch. Naval Brass Bolts
2¼ × 2¼ × ⅜ Angle Frame
3½ × 2 Oak Frame
¾ Naval Brass Bolts Chesse Heads

Fig. 9. No. 8. STATION.
¾ Cch. Naval Brass Bolts
2¼ × 2¼ × ⅜ Angle Frame
3½ × 2 Oak Frame
¾ Naval Brass Bolts Chesse Heads
¾ Naval Brass Cch. Heads
¾ Naval Brass Deadwood Bolts

propellers, and gave valuable information, deciding the proper pitch and blade area (see Fig. 12).

It will be some time before this boat is completed but, from these tank tests, there is every reason to be confident the results will prove as expected.

The construction is somewhat peculiar. She has a double skin of teak, experience having demonstrated that a wood boat of this construction, if she happens to get ashore, will stand far more punishing than a steel boat—whether on a sandy or a rocky shore. She is divided by many transverse, and a few longitudinal, watertight bulkheads, these being of steel; and in addition air cases are fitted wherever possible. The fore and aft stringers are fitted outside the planking—not only to give protection, but to enable the transverse bulkheads to be more simply constructed. The boat is flush decked and has two cabins, one forward and one aft of the machinery compartments. It is expected these cabins will be of enormous benefit to the rescued, probably in many cases saving life owing to prompt restorative treatment being possible.

As will be observed, each main engine is in a watertight compartment. There is an auxiliary engine compartment containing an electric plant for lighting, also for charging an air compressor for the windlass and the capstan, which are air driven. The main engines are of the Institution's new type, and all controls are led to deck, under shelter at the aft end of the engine casing. Everything may therefore be operated from deck. All the other features and details of this lifeboat can be seen from the drawings. She has large petrol tanks, and will have a cruising radius of 150 miles, and thus has very valuable possibilities. This 60-ft. lifeboat being purely a power vessel, has only small sails for steadying her.

3. One more development by the Lifeboat Institution may be briefly noticed. The necessity for providing a cabin wherever possible, has been strongly advocated. Therefore boats of the present 45-ft. non-self-righting

RECENT DEVELOPMENTS IN MOTOR LIFEBOATS.

Fig. 10. NON-SELF-Rrighting 45 Ft SAILING LIFE-BOAT WITH CABIN

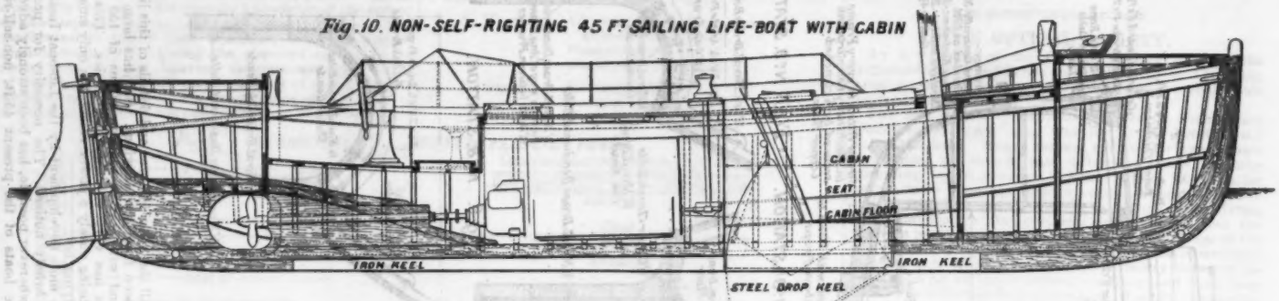


Fig. 11.

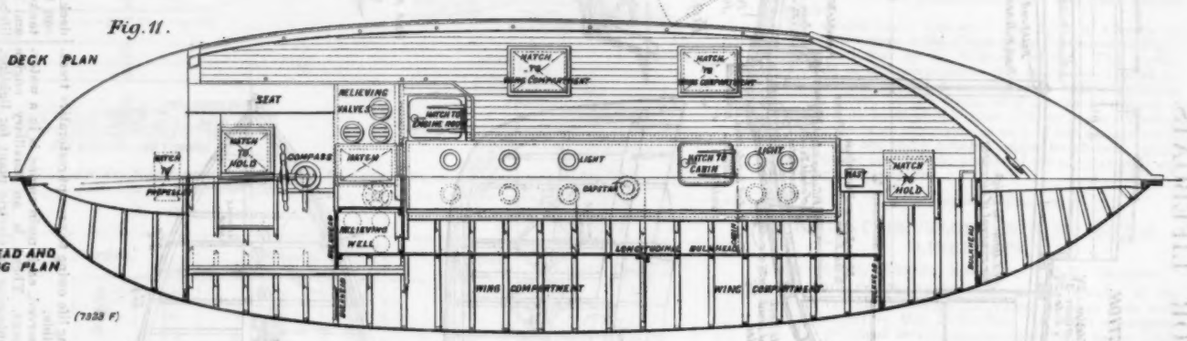


TABLE I.—SELF-RIGHTING TYPE.

Dimensions of Lifeboat.	Engine.					Propeller.		Speed.	Fuel.	
	Cyls.	Dia.	Stroke.	R.P.M.	B.H.P.	Dia.	Pitch.	Knots.	Pints per Hour.	Gallons Capacity.
		in.	in.			in.	in.			
35 ft. by 8 ft. 6 in.	4	2¾	5	850	15	17	16	5·9	—	20
38 ft. by 9 ft. 9 in.	4	5	5½	750	35	20	20	7·0	31½	50
38 ft. by 9 ft. 9 in.	4	5	5½	950	45	18½	17	7·49	35	50
40 ft. by 10 ft. 6 in.	4	5½	6½	700	40	22	22	7·47	34½	60
40 ft. by 10 ft. 6 in.	4	5½	6½	825	—	22	19	7·5	34	60
40 ft. by 10 ft. 6 in. (building)	4	5	6	950	45	22	19	—	—	60
42 ft. by 11 ft.	4	5	5½	800	30	22	21	6·65	21	50

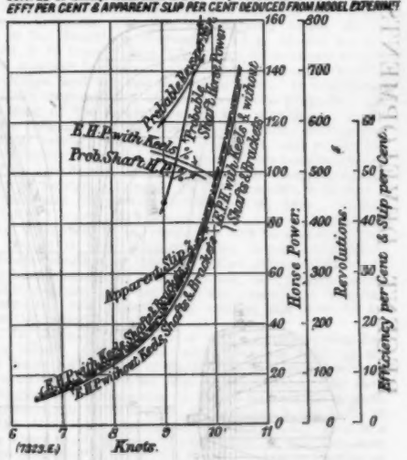
TABLE II.—NON-SELF-RIGHTING TYPE.

Dimensions of Lifeboat.	Engine.					Propeller.		Speed.	Fuel.	
	Cyls.	Dia.	Stroke.	R.P.M.	B.H.P.	Dia.	Pitch.	Knots.	Pints per Hour.	Gallons Capacity.
		in.	in.			in.	in.			
38 ft. by 10 ft.	4	5	6½	700	34	21	21	7·15	33½	50
40 ft. by 11 ft.	4	5½	6½	700	40	20	22	7·22	34½	50
40 ft. by 11 ft.	4	5½	6½	825	—	22	19	7·5	34	60
43 ft. by 12 ft. 6 in.	4	5½	6½	700	40	22	21	7·5	36½	60
43 ft. by 12 ft. 6 in.	4	6½	6½	700	40	24	22	7·4	36	60
43 ft. by 12. ft 6 in.	4	6½	7½	700	60	24	26	7·6	38	60
45 ft. by 12 ft. 6 in. (no tunnel)	4	5½	6½	700	40	24	20½	7·63	40	60
45 ft. by 12 ft. 6 in.	4	6½	7½	700	60	24	22	7·75	50	80
				750	60	24	22	8·08	50	80
45 ft. by 12 ft. 6 in. (building)	6	5½	7	800	76	—	—	—	—	80
46 ft. 6 in. by 12 ft. 9 in. (no tunnel)	4	6½	7½	700	60	24	22	8·3	50	80
46 ft. 6 in. by 12 ft. 9 in. (building, no tunnel)	6	5½	7	800	76	—	—	—	—	80
60 ft. by 15 ft. (building, twin screw)	6	5½	7	800	76	26	22	9·75	—	—

Fig. 12. T.S. MOTOR LIFEBOAT D.W.L. 58·5' x 15' BREADTH EX. MOULDED DRAUGHTS. F. 3'0 A. 4'0 MEAN 3·5'
DISPLACEMENT 41·8 TONS (INCLUDING BOSSES & KEELS)

PARTICULARS OF PROPELLERS { DIAMETER ..... 2'6" PITCH ..... 2'3" No. OF BLADES 3 COND. AREA = ·488 DISC AREA

CURVES OF E.H.P. PROBABLE SHAFT H.P. PROBABLE REVS. PER MIN. EFFY PER CENT & APPARENT SLIP PER CENT DEDUCED FROM MODEL EXPERIMENT



NOTE.—It will be seen that the speed which will be attained with 150 b.h.p. will be very slightly less than 9½ knots, but the revolutions per minute for the propellers proposed will only be 720 at this speed instead of 800, as is required by the engines to develop this power. It will be necessary in order to obtain the required revolutions per minute to reduce the pitch to 23 in.; this should not sensibly reduce the efficiency. In view of the high slip for still-water conditions it also seems that it would be advantageous to increase the ratio of projected blade area to disc area from 0·488 to, say, 0·7 to meet the contingencies of lifeboat service.

type (Figs. 10 and 11) are in future being built with a cabin, and the Institution's new engine (of similar power to the engine in the 60-ft. boat) is to be installed in them). In these boats it has, however, been found desirable to retain sails and a centre-board. Tables I and II give a few particulars of the different sizes of Institution motor lifeboats.

THE LOCOMOTIVE ENGINEERS' POCKET BOOK.—The little annual known as the Locomotive Engineers' Pocket Book, published by the Locomotive Publishing Company, Limited, 3, Amen-corner, Paternoster-row, E.C.4, at the price of 3s. 6d., is not much changed in its 1922 edition from the form in which it last appeared. Excepting for its inadequate index, this little book forms really a serviceable compendium of information on locomotive design and practice. It does not pretend to be exhaustive, but it gives in condensed form a good deal of material which it is often very difficult for the designer to put his hand on. There are a few additions in this year's issue. A new diagram of vased-sines is presented in connection with curves. The section on laminated springs formerly based on D. K. Clark and comprising load and deflection diagrams, has now been re-cast and elaborated by Mr. T. H. Sanders, who has got together a number of designing hints in addition to formulæ, etc. Another new section is devoted to a discussion of plate and bar frames, while the quasi-arc electric welding process is also described for the first time in connection with locomotive repairs. The book is furnished with diary space and leaves of black and square paper, as usual, for notes, etc.